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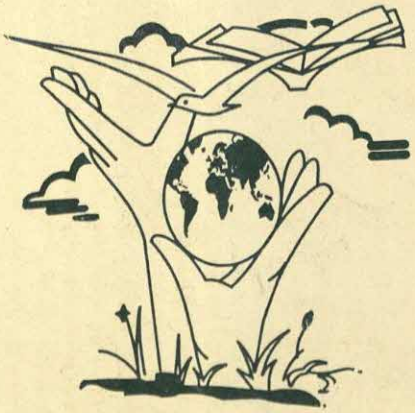
TRAINING MANUAL FOR
GLOBE
TEACHERS

Capacity Building for Hands-on Participatory Environmental Learning Under Environmental Education in School System
World Bank



Prepared By:
Indian Environmental Society

Supported By:
Ministry of Environment and Forests,
Govt. of India

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11.11.2010
14284

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Table of Contents

Chapter I The Globe Program 1
- Overview
- The goals of GLOBE
- Globe Science and Education
- GLOBE Science and Inquiry Processes
- What will You and Your Students do in The GLOBE Program
- Six key educational elements of the GLOBE Programme
- Science values and GLOBE Measurements
- GLOBE Measurements in Time and Space
- Domains of GLOBE Research
- Values of GLOBE Student Data
- Implementing GLOBE in Your School
- Selection of your GLOBE Study Site
- How to Make GLOBE a Meaningful Scientific Project For Students
- How to Help Students in Designing their Own Investigations
- Some thoughts to keep in mind as you proceed
- GLOBE Outreach

Chapter II Global Positioning System (GPS) 23
- Overview
- GPS Satellites
- How to Perform the GPS Investigation

Chapter III Atmosphere Investigation 28
- GLOBE Measurements
- Atmospheric Protocols
    - Cloud Type Protocol
    - Cloud Cover Protocol
    - Contrail Type Protocol
    - Contrail Cover Protocol
    - Rainfall Protocol
    - Solid Precipitation Protocol
    - Precipitation pH Protocol
    - Maximum, Minimum and Current Temperature Protocol
- Building A Thermometer
- Land, Water and Air

Chapter IV Soil Investigation 55
- GLOBE Measurements
- Soil Protocol
  Soil characterization protocols: In the Field
    Soil Structure
    Soil Colour
    Soil Consistency
    Soil Texture
    Roots
    Rocks
    Test for free carbonates
  Soil Characterization Protocol: Lab Measurements
    Soil pH
    Bulk density
    Soil particle distribution size
  Soil Moisture and Temperature Protocol: Field Measurements
    Gravimetric Soil Moisture Protocol

Chapter V Hydrology Investigation 77
- GLOBE Measurements
- Hydrology Protocol
    Water Transparency Protocol
    Water Temperature Protocol
    Dissolved Oxygen Protocol
    pH Protocol
    Electrical Conductivity Protocol
    Salinity Protocol
    Optional Salinity Titration Protocol
    Alkalinity Protocol
    Nitrate Protocol

Chapter VI Land Cover Investigation 107

- GLOBE Measurements
- Investigation Instruments
  - The MUC System
  - Densiometer
  - Clinometer
- Land Cover Protocol
  - Land Cover Sample Site Protocol
  - Biometry Protocol
  - Canopy cover and Ground Cover
  - Graminoid, Tree, and Shrub Height Protocol
  - Tree Circumference
  - Dominant and Co-dominant Vegetation
  - Manual Land Cover Mapping Protocol
  - How to enter your observations on the Land cover/Biology Investigation Field
  - Data Worksheet
  - MUC System Protocol
  - Accuracy Assessment Protocol
- Seasons

Chapter VII Frequently Asked Questions 135

Chapter I

THE GLOBE PROGRAM

Overview

Global Learning and Observations to Benefit the Environment (GLOBE) is a hands-on international environmental science and education programme. GLOBE links students, teachers and the scientific research community in an effort to learn more about our environment through student data collection and observation.

The goals of GLOBE

To enhance the environmental awareness of individuals throughout the world;

To contribute to scientific understanding of the Earth;

To help all students reach higher levels of achievement in science and mathematics.

Students from the ages of approximately five through eighteen years in schools throughout the world would conduct a continuing program of scientifically meaningful environmental measurements. GLOBE students transmit their data to a central data processing facility via the internet, receive vivid images composed of their data and data from other GLOBE schools around the world, acquire information from a variety of sources and collaborate with scientists and other GLOBE students and communities world-wide in using these data for education and research.

The measurement taken by the GLOBE student serves two important purposes:

- Participating scientists' use these data in their research programmes to improve our understanding of the global environment.

- Students not only learn how to carry out a scientifically rigorous programme of Earth observations, but also learn to use their own measurements, together with data from other GLOBE schools, as a key part of their study of environmental science. Through contact with and mentoring by scientists, the students receive feedback about the value of their data sets in world-class scientific research.

GLOBE provides extensive educational materials to enrich the learning experience of participating students. These materials include a wide variety of classroom and field activities to help students place their measurements in a broader context and relate their own local observations to global environmental issues.

GLOBE Science and Education:

GLOBE is science and education, not just science education. GLOBE teachers and students join with research scientists to form broadly distributed research team. Students collect data that are valuable to these researchers' work on various inquires. This collaboration and the authenticity of the data collected stimulate learning and offer opportunity for dynamic new approaches to education.

Behind every GLOBE measurement protocol and instrument specification is a science research team committed to the use of data collected by the students following these protocols.

As a science and education program, GLOBE neither begins nor ends with data collection. Scientists collect data to gain understanding, and students can do the same. Teachers are encouraged to stimulate and reinforce their students' natural interest in their surroundings. Student's interest can take form of questions that they want to answer, and taking data is part of addressing their questions. Recording, assembling and analysing data are a necessary part of the process leading to answers, new insights, and refined questions and data reporting is essential for GLOBE implementation to give students an authentic science experience.

GLOBE Science and Inquiry Processes

The teacher's guide facilitates the learning of science by use of the inquiry process. The inquiry process used by the GLOBE programme is an approach to learning, which parallels the scientific method used by scientists. This process is represented in the combined package of the protocols and learning activities. The protocols focus on data collection and data reporting. The activities broaden from the data collection and data reporting to include other parts of the inquiry process such as formulation of hypothesis, analysis of data, and drawing of conclusions.

The science process used by researchers' parallels the inquiry process used at the K-12 level. The primary difference is the outcome for each group. In schools, the primary outcome is learning science. At the research level, the outcome is generation of knowledge. The data collection and data reporting done by the students provide data to the research community and these data are used in the generation of new knowledge. The scientific research community analyzes the data, draws conclusions and reports, which are communicated back to the teachers and students.

GLOBE is the "quintessentially ideal program for involving kids in science. From the practical standpoint, GLOBE can benefit teachers and students in the following ways: -

- GLOBE is an interdisciplinary program.
- GLOBE Learning Activities and Protocols are aligned with the National Science Education Standards.
- Independent evaluations show that the GLOBE improves students' higher order thinking and science process skills.

What Will You And Your Students Do in the GLOBE Program?

Your students will be carrying out a series of investigations the scientists have designed to gather data about the Earth and how it functions as a global system. Students will be using instruments and their own senses to observe the environment at multiple sites near your school. They will record the data they gather, save it in a permanent school data record, and send it to the GLOBE Student Data Server using the Internet and the World Wide Web or E-mail where the Web is not readily available.

In addition to carrying out these measurements in collaboration with GLOBE scientists, GLOBE teachers have the options of doing some of the learning activities with their students, either as described here, or in whatever form is most appropriate for their local curriculum needs.

The learning materials provide a range of activities, from beginning activities to be used by teachers of young children who might have had little to no experience with science, to more complicated activities for the advanced level. Each learning activity provides the background information needed to successfully complete the activity.

Each of the protocols and learning activities includes a designation of recommended grade levels, in three categories.

Primary	–	Ages 5-9 years
Middle	–	Ages 10-13 years
Secondary	–	Ages 14-18 years

Many of the activities can be adapted to lower or higher levels, based on your students' needs and abilities.

Your students will observe and make measurements, record their data, come to understand accuracy and precision, share their data with other students and scientists, conduct labs, formulate questions, test hypothesis, and develop theories to make sense of the data. They will use a variety of scientific instruments, calibrate those instruments, and try to understand potential sources of error in the measurements they take with the instruments. They will work with real data, some that they collect and some that they obtain from other GLOBE schools around the world.

Six Key educational elements of the GLOBE Programme

1. **Selecting local study and sample sites:**

   Based on guidelines provided here, you will pick local study sites for your recurring measurements along with sample sites, which the students will normally visit only once. For example, the hydrology study site should be a nearby river, lake, bay, ocean or pond. All of the study and sample sites will be within your 15km X 15km GLOBE Study Site, with your school at its center.

2. **Taking Measurements Carefully on a regular schedule:**

   Students should begin with one measurement and then over the course of a few months, add new measurements one-by-one as they learn how to do them. Teachers need to make sure that the students understand and do the measurements accurately. Most of the measurement protocols specify a regular schedule for taking data and some require observations at specific times. Weather measurements, which are daily, can be done most easily at a sight adjacent to your school. Others such as the weekly hydrology measurements will require going to the selected study site.

3. **Submitting the Data:**

All data should be submitted to the GLOBE Student Data Server. The most common way to submit data is by computer and the Internet; E-mail submission of data is also possible using a spreadsheets.

4. **Complete the Learning Activities:**

Each investigation has a set of learning activities that help your students learn more about the science domains, the instruments and procedure for the measurements, and the ways that students and scientists can use the data collected. Your experiences in using these learning activities or new learning activities you develop can be shared with other GLOBE teachers to benefit the entire program.

5. **Using GLOBE Systems on the Internet to explore and communicate:**

GLOBE has created some powerful (and easy to use) computer software, which enables you to communicate with other schools and with the GLOBE scientists. It also lets your students see and interact with local and worldwide maps on which the GLOBE data are displayed.

6. **Promoting Student Investigation:**

Ultimately, our hope is that your students will do their own investigations at local sites, or by using the GLOBE software and data collected by other student's Worldwide. Your students might even make some new scientific discoveries of their own.

Science Values and GLOBE Measurements:

There are four characteristics needed in GLOBE measurements that will form a foundation for their ultimate contributions to science. These are as follows:

- **Accuracy**

Accuracy is the foundation of all scientific observation. For us, accuracy in taking the measurements is the first step. Also, the equipment we use and our effort to keep it in good condition are important. Lastly, we all need to strive for perfection in recording data entries and reporting them to the data archive.

- **Consistency**

  Consistency means that the data from any GLOBE school can be used together with the data from all the others to produce a consistent picture of what is happening around the world other than our own individual sites. Consistency is also important over time. Students at each school are building a climate record of their location. To see changes and trends in our individual environments, the data that have been taken in the past must be directly comparable to the data we are taking today. Careful adherence to the protocols and documentation of changes in our methods and techniques are the best approaches in achieving these characteristics.

- ***Persistence***

  Persistence is required to keep interruptions in our climate records to a minimum. Occasional measurements are useful, but regular observations provide more information allowing a greater understanding of what is happening at a measurement site. Also, regular observations are often easier to interpret and are used with greater confidence, especially when unusual phenomena are measured. The longer a consistent climate record is, the more valuable it is.

- ***Coverage***

  Coverage of whole regions, countries, continents and as much of our planet as possible also will enhance the value of our data sets. The properties of our environment vary over many different spatial scales-locally within our 15 km by 15 km GLOBE Study Sites, regionally across our metropolitan areas, states or countries and globally. Measuring these properties on these different scales is essential, and as the GLOBE programme grows to include more schools in more countries, the importance of our collective contributions will continue to grow.

GLOBE Measurement in Time and Space

We live on a changing planet. Moment by moment, day-to-day, year after year change is all around us. Some changes are cycles such as the day, the variations in the tides as the moon orbits the Earth, and the yearly changes of the seasons. Other changes seem to come and go such as clouds and rainstorms. Sometimes big changes happen quickly as when a volcano erupts or a fire sweeps over the land. Each type of change happens on its own time scale.

All of us, especially scientists, want to understand the changes happening all around us. Why do changes happen, how do different changes influence each other, what will happen next? To understand change, and in some cases predict it, we must measure our environment, but we can't measure everything happening in our environment, everywhere all the time. Instead we try to make measurements in a way, which will give us enough data to tell what is happening locally so that we can make comparison on a worldwide scale.

In GLOBE, the atmospheric measurements are designed to be made once each day while streams, rivers, lakes, bays, the ocean or ponds are measured weekly and soil characteristics in a given place need only be measured once. Other measurements are snap shots – what types of cloud do we see right now? Some measurements tell us what has happened over a period of time-how much rain fell in the last day? The time scale on which we make the measurements allows us to analyse the different changes in our environment.

Our environment also varies from place to place. We live on mountains, valleys, plains, and coasts. So our environment varies on different distance scales.

We cannot measure everything about our environment everywhere. So we space our observations so as to measure the variations on their different spatial scale. In GLOBE, each school is at the center of a GLOBE study site, which is a square 15 km on a side. These sites can overlap or be shared among schools. As the number of GLOBE school increases more of our global environment is covered by good measurements and variations over smaller distances can be studied. With all the changes in our environment over time and variations over space, our ability to understand our environment is limited by the number of measurements we can make. Each GLOBE school has the opportunity to add significantly to the total set of measurements being made around the world.

Domains of GLOBE Research

In the broadest sense, the entire planet earth is the domain of GLOBE science research. By collecting environmental data from around the world, scientist (and students) will have a better understanding of earth and its interrelated cycles.

While scientists already have access to much data about Earth, GLOBE students will provide important new data to help the scientists.

Values of GLOBE student data

- The GLOBE student data is that it is worldwide, providing measurements from thousands of locations.
- Students do several different types of measurements at the same time, enabling scientists to study how Earth's air, land, water and biology systems interact.
- GLOBE students contribute their own analyses of local study sites, becoming in a real sense the world's experts on their own study areas, which will in turn help scientists in their research.

Currently, there are four domains of GLOBE scientific research. Each is detailed in one of the GLOBE investigation: -

- **Atmosphere**: - Students conduct daily measurements of cloud and contrail cover and type, air temperature, precipitation and its pH.
- **Hydrology**: - Students do weekly measurements of water transparency, temperature, dissolved oxygen, pH, either conductivity or salinity, alkalinity and nitrate-nitrogen of a water body near the school.
- **Soil**: - Students expose a soil profile, take soil samples and analyze them to determine the characteristics of various soil layers. They also do daily to monthly measurements of soil moisture at various depths and locations, and take weekly measurements of near-surface soil temperature.
- **Land Cover / Biology**: - Students study the type of land cover in their land cover study site, a 15 X 15 km area centered on their school. They visit multiple land cover sample sites where they determine the type of land cover and measure the amount of species of vegetation. They then create a land cover type map of their study site on analysis of satellite imagery of the area and the observational data collected.

In addition to these direct investigations, there are two supportive investigations included in GLOBE.

- **GPS**: - The Global Positioning System (GPS) is a new technology that enables you to determine the latitude and longitude, and elevation of various sites using a small hand-held receiver and set of Earth-orbiting satellites. This information is essential so that scientists and others will always know where your measurements were taken.
- **Earth as a System**: - This investigation is presented in two parts. In the first, Seasons and Phenology, students will study biological indicators of seasonal

changes. The second part of the Earth as a System Chapter, Exploring the Connections, contains learning activities that help students understand the connections between different aspects of the natural world on a variety of scales, ranging from their own school yard to the entire earth.

Implementing GLOBE in your School

1. **Obtaining Instruments**: Each of the investigations requires use of accurate, reliable and calibrated instruments that meet the specifications developed by the GLOBE scientists to ensure consistent and accurate measurements for use by the international environmental science community.

For obtaining instruments you have four choices:

1. Purchase all or some of the instruments: - If the school has got good infrastructure, then the GLOBE school can purchase all or some of the GLOBE instruments.
2. Use your own instruments: - If you already have instruments that meet GLOBE specifications in your school, you may use them. You must be sure, however, that they meet the accuracy and calibration requirements.
3. Make some of your instruments: - Some of the GLOBE protocols require simple instruments like densiometer, clinometer, rain gauge etc. which can be easily prepared by the school students.
4. Borrow instruments or share some of the instruments with other schools: - You may be able to borrow instruments that are needed infrequently from another local school or share one instrument among two or more GLOBE schools. In the case of the GPS receiver, it is available on loan from GLOBE or through the GLOBE Country Coordinator.

2. **Training and Implementation**: Every teacher who takes responsibility for the GLOBE measurements must have attended one GLOBE sanctioned workshop. Teachers who have received GLOBE training must undertake the responsibility of making sure that the others in their school receive correct training. If you have attended GLOBE workshop and are comfortable implementing new GLOBE measurement protocols, then you are encouraged to do so even though your training may not have covered them. If you are uncomfortable with the new protocols, you can obtain assistance from the GLOBE Help Desk or obtain another training workshop.

3. Establish Learning Communities

1. School Learning Community: - An effective, interesting and exciting way to implement GLOBE in your school is to involve many teachers. If you can share the work with colleagues, it will make it easier and more fun. It is helpful for you to have colleagues with whom you can share ideas, brainstorm and plan. Research and experience have shown over and over again that innovative programmes such as GLOBE have a better chance of success if they are undertaken by a team of mutually-supportive teachers than if tackled alone.

   One strategy for building a learning community in your school is the development of a school implementation plan which details a division of labour among teachers at the school for the implementation of the various GLOBE topic areas - Atmosphere, Hydrology, Soil and Land Cover Biology.

   The plan could identify the most appropriate locations in the school curricula for integrating each of the GLOBE areas. The plan also describes how equipment and computer facilities will be obtained and factored into the instrumental plan.

   A timetable for all major activities is desirable: - In order to provide an identity for your school learning community and for GLOBE activities in your school. You may establish a GLOBE headquarters in some prominent location, perhaps in the library or in common room. Here you can establish GLOBE posters, have a collection of books about planet Earth, display student work.

   In addition, you may want to place posters and other materials in a prominent place near the school office or entrance identifying your school as a participant in the GLOBE Programme. Students may create ongoing displays of the data they are collecting. Photos of students at the study and sample sites making measurements and maps locating there sites will inform viewers of the scope of your work.

2. Neighborhood Learning Community: - Another area where you might build a learning community is in your neighborhood. There are many people and organizations, which may be interested in your GLOBE activities. For example service clubs such as Rotary business and industry or other organizations, may be willing to provide support for equipment purchases,

research activities or presentations. Community volunteers, including parents may be able to help with a variety of GLOBE related tasks or activities. It is important to cultivate an ongoing relationship with key members of community. Let them know about successes and plans. Publicize events and invite them to attend.

3. Geographically Distributed Research Learning Community: - It is also possible to establish geographically distributed research teams, which can become a wider learning community. Schools in various parts of a community or the world can collaborate on research activities. Your research community can be expanded by inviting GLOBE scientists or other researchers to participate as mentors and provide support for your school-to-school investigation.

Selection of your GLOBE Study Sites

Initial Considerations

The selection of the local study and sample sites can be an opportunity to begin an inventory of the area around the school, and to discuss criteria for measurement sites. For each measurement site within your GLOBE Study Sites there will be hard choice to make because no one will have a perfect set of locations. This is an opportunity to work on solving problems with your students in order to come up with the best arrangement for your class, your school, and your schedule. Involve your students in site selection.

GLOBE Study Site

Your GLOBE Study Site is the 15 Km X 15 km area centered on your school. All of the smaller study sites are located within this large GLOBE Study Site. Within your 15 km X 15 km GLOBE Study Site, you will select several specific study sites, corresponding to the individual protocols - Atmosphere, Hydrology, Soil Moisture and Land Cover Biology. Once established, these Study Sites are locations to which students will return again and again to take measurements. The Land Cover and Soil Characterization Protocols involve measurements, which are done only once at specific locations which are referred to as sample sites.

Using GPS Receiver to Determine the Location of your School and Sites

The GLOBE Program owns GPS receiver, which are maintained by the University Navstar Consortium (UNAVCO) Country coordinators, may request to borrow GPS receivers from UNAVCO for use by their GLOBE schools.

Selection of various study sites

1. Atmosphere Study Site

In the atmospheric study site, students will measure temperature, precipitation, cloud type and cloud amount. Since these are daily measurements, your Atmosphere Study Site should be located on or near your school grounds, so that students will have easy daily access to the instruments.

Some Special Considerations

1. Measurements of cloud amount and cloud type require an unobstructed view of the sky. The middle of a sports field or parking lot is an excellent location.
2. For measurements of precipitation, the rain gauge must be in an open area with a natural surface. Do not place the rain gauge close to buildings, trees or high bushes, which can affect the amount of rain that collects in the rain gauge. An open field, a playground, or the side of sports field are excellent location for the rain gauge. The snowboard should also be placed in an open area away from building.
3. For measurements of temperature, you need to put the thermometer in a small standardized, protective shelter. This shelter, painted white, with slats on the sides to let air circulate, is mounted on a post. The shelter has a door, enabling students to look in to read the temperatures. The instrument shelter should also be placed in an open area with a natural (eg. Grassy) surface, away from buildings, trees or high bushes.

   If possible, place the rain gauge within 100 meters of the Soil Moisture Study Site, as the rain data will help students and scientists better understand the soil moisture data.

Note: Some schools cannot meet all these criteria for locating their Atmosphere Study Site. GLOBE encourages such schools to describe carefully all the ways in which their site differs from the criteria given here and to report this information on the Atmosphere Study Site Definition Data Entry Sheet.

2. Hydrology Study Site

There are two steps to selecting your Hydrology Study Site. First you need to determine which bodies of water (streams, rivers, lakes, the ocean, ponds and reservoirs) are in your GLOBE Study Site. Second, you need to select one that is most appropriate for the Hydrology Investigation. Ideally, the Hydrology Study Site should be within 15 km X 15 km GLOBE Study Site and connected to water systems that flows into larger river or estuary systems. This means that if your site includes more than one watershed, you have to figure out which one is most important. Within this watershed, select a specific site where the hydrology measurements will be taken.

If the selected study site is a moving body of water (i.e. stream or river), locate your sampling site at a riffle area as opposed to still waters or rapids. This will provide a more representative measurement of the water in the stream or river.

If the selected study site is a still body of water (i.e. a lake or reservoir), find a sampling site near the outlet area or along the middle of the water body. Avoid inlet areas. Hydrology measurements should be taken weekly and therefore it is important that your study site be easily accessible to students on a routine basis.

3. Soil Study and Sample Sites

For the soil Investigation, there are two types of Sites. Soil Characterization Sample Sites and a Soil Moisture Study Site.

At Soil Characterization Sample Sites, holes will be dug to expose the soil profile and permit the collection of soil samples and the examination of the various soil layers or horizons. One site should be located within the Biology Study Site in order to link the soil type with land cover characteristics. A second site should be located as close as possible to the Soil Moisture Study Site. In this way, the soil properties needed to interpret soil moisture measurements can be determined.

At Soil Moisture Study Sites, either of two soil moisture measurement techniques may be employed. The first uses a technique called gravimetric sampling and simply involves collecting soil samples and drying them to determine their moisture content. Samples are collected 12 times during a year, and you and your students from a set of options choose the timing and pattern of collection.

The second, which is optional and only recommended for advanced students in areas where the soil is not acidic, involves burying gypsum block moisture sensors at four specified depths in the soil and collecting readings from the sensors on a daily basis.

To enable correlation of the atmosphere data with the soil moisture and the temperature data, a soil moisture study site must be located within 100m of rain gauge in the atmosphere study site. This results in there being a single atmosphere and soil moisture study site.

4. Land Cover / Biology Study and Sample Sites

Land Cover Sample Sites, which are used to document land cover characteristics, are 90m by 90 in size. The site must be in an area with similar (Homogenous) cover. These characteristics are needed to enable verification of satellite data. Land Cover Sample Sites, which are used to document land cover characteristics, are 90 m by 90 m in size.

How to Teach a Protocol

When you teach your students a new protocol, use the following steps. This procedure with minor modifications can be used to teach students nearly all of the GLOBE protocols.

Good Education = Good Data = Good Science

If you do a good job of teaching the protocol, then your students will submit good data. If they submit good data, then you can extend the learning opportunities by having your students analyze their own data and data from other schools. This in turn helps them better understand the science domain and get even better at their measurements.

Phase – I

Getting Ready

- Students read the letter from the scientist: - At the beginning of each investigation, copy and distribute a personal letter from the GLOBE scientists who are leading the investigations. When they read this letter, your students start to make a personal connection with the scientists.
- Students read the Interview with the Scientists: - Immediately following the letter from the scientists, is an interview in which the scientists talk about their background, their work as scientists, and why they need your data. Also, the interview contains interesting anecdotes to further personalize the scientists.

- What are you measuring?

Through use of GLOBE learning activities, discussions, or field trips, you need to make sure your students understand the basic concepts included in the protocols they are performing. In reality, your students may not really understand the concept until they are fully engaged with the measurement process. However at this stage they at least need to have an introduction to the concepts.

Phase II

Selecting the Study Site

- Understand the guidelines for selecting the study or sample site for each measurement: - Every protocol includes some carefully prepared guidelines on the selection of the study or sample site for each measurement. Review these with your students.
- Select the study or sample site: - Based on maps of your region, the Landsat image, personal familiarity with the region and a field trip with your students, select the study or sample site. Review the criteria to be sure that the site matches the criteria. Convenience to your school is generally helpful in selecting sites, which should remain the same from year to year.
- Visit the study site: - If possible, take your students on a field trip to observe the study site.

Phase III

Learning and Practicing the Protocol

- Introduce the instrument: - Most protocols use some type of special instruments to do the measurement. Show the instruments to the students. Explain how it works.
- Demonstrate the protocol: - Following the procedures detailed in the protocol, demonstrate the steps of the protocol. In most cases, you can demonstrate the experiments in the classroom. Also write the steps of the protocol on the board or on poster paper for students to follow them.
- Students practice the protocol: - Make your students, individually or in team, to practice the same steps that you demonstrated, watch them carefully and help them in perfecting their techniques.

- Record and discuss the practice data: - Make sure that students have recorded the data practiced by them in their record books/appendix. Review these measurements with students and discuss the range of results. If the students have any abnormal/out of range results, discuss with them why this might have occurred. This introduces the concept of data quality, which is the most essential part of the GLOBE Program.
- Submit the data: - Use the GLOBE web pages to submit the recorded data to the GLOBE data Server, after returning to the classroom or laboratory.

Phase IV

Submitting and Using the Data on an Ongoing Basis

- Do the protocol on the prescribed schedule throughout the year.
- Data quality requires ongoing attention.
- Students use the data for their own investigations.

Phase V

Doing the Real Thing

- Get all your materials ready and go to the study site - Have your students gather the instruments, the data recording sheet, pens or pencils, and any other materials that are needed to do the measurement. Go to the study site with your class taking the materials along.
- Demonstrate the full protocol at the study site - Your students have practiced most of the protocol in the classroom, but there may be new elements for them to learn, now that they are at the actual study site. Demonstrate the full protocol and make sure your students understand it.
- Students do the real protocol at the study or sample site - Have your students do the protocol step by step. Watch closely to make sure that they are doing everything correctly.
- Check the data for reasonableness

How to Make GLOBE a meaningful Scientific Project For Your Students

GLOBE can be a terrific scientific experience for your students. Through participating in a genuine global research project, in which scientists have designed the investigations; they experience firsthand the excitement, the rigor and the challenges of real science. Here are some things you can do to help make GLOBE an exciting scientific experience for your students.

- Stress that the Scientists Need Your Data

The GLOBE program is unique in the degree to which scientists will actually use the data collected by students. Students will be motivated to put out the effort to obtain quality data only if they understand the science behind the protocols, understand the importance of their data to the scientific enterprise and support the overall research project.

- Personalize the GLOBE Scientists for Your Students

Use the photographs of the scientists, their interview to introduce the scientists to your students on a personal level. On the GLOBE website you will find a section called the Scientists cover. Have your students visit this page to view online photographs of the scientists and to read reports from the scientists about their work with the GLOBE program.

- Encourage Students to Contact Other GLOBE Schools

One of the exciting things about the GLOBE Program is that it provides opportunity for students to meet, communicate with, and work with students in other schools around the world.

- Use GLOBE Telecommunications

Through the GLOBE Web Site, you can: obtain bulletins and updates; read background information about the program; interact with the scientists and other schools; submit your data; examine and retrieve data from other schools; look at graphic representations of both the GLOBE student data and other global data model prediction; and exchange GLOBE mails with other GLOBE students.

- Use GLOBE Science Notebooks

Encourage your students to keep a GLOBE Science Notebook, a scientific journal or notebook where each student can record all kinds of thoughts and observations. Students can record reflections, ideas, hypothesis, questions, observations and sketches as well as transcribe lab results and data as they progress through their GLOBE work.

Each entry in the GLOBE science notebook should include

- Date
- Location
- Time

- If a field entry, environmental variables such as weather
- Questions, hypothesis, methods, observations, analyses, conclusions, ideas

The information gathered in the GLOBE Science Notebook should be used to help students prepare papers and presentations on their investigations and projects.

How to Help Your Students Design Their Own Investigations

Encouraging students to conduct science investigations is at the heart of GLOBE's approach to education. Students can use data from their own GLOBE Study Site, as well as data from other schools to ask questions, seek answers by looking at real data, pursue their own interests, establish partnerships with other schools throughout the world, and explore the interconnections among the various phenomena which comprise the Earth System. Students may design their own investigations as well.

Some thoughts to keep in mind as you proceed

1. The nature of your investigations will depend on local factors - The exact nature of student investigations will vary from school to school. It will depend on the characteristics of your own GLOBE study site, the GLOBE data you use, the interests and expertise, the capabilities and expertise that is made available to your students from their community, the technology available to you, the age and experience level of your students and the amount of time that you have available.
2. Investigations should be based on student's questions - Investigations begin with questions. Even if you focus students on a specific area, the investigations themselves must begin with questions that the students are sincerely asking.
3. Students should take direct observations - Students investigations should be grounded in their observations of the phenomena they are studying.
4. Students should use data from the GLOBE Student Data Server - This database of student observations is a unique and valuable resource to support student research and learning
5. Students should build on what they know - Students will collect data for the atmosphere, Hydrology, Soil and Land Cover / Biology Investigations. They should also do a variety of related learning activities to strengthen their understanding of the measurement protocols and resulting data. The investigations should build on this knowledge base.

6. Students should trap other sources of information - Students should pursue other sources of data and representations of these data's such as images, graphs, tables of data and other visualizations available through GLOBE.
7. Students should collaborate with other GLOBE students throughout the world - GLOBE epitomizes this in the scientists' reliance on data from thousands of students worldwide. Most Earth scientists work in teams because of the extensive nature of environmental research. So students' investigations usually are strengthened or enabled by collaboration among several students who divide the responsibilities and share their thoughts.
8. Your students can do investigations at any point in the year - The best time for an investigation is when the students are truly engaged and curious about something they see at their study site, in the GLOBE data, or in the news.
9. Investigations can be short or long - Help your students to set achievable objectives so that they can see results from their work before they loose interest. Generally there may be no single right answer. Students tend to assume that answers are either right or wrong, but for many questions, there is no single right answer
10. Most investigations are interactive and messy - In many cases; one does not simply state a hypothesis. The process involves asking many questions, exploring the data, making questions exploring the data, making guesses, doing more observation, rethinking the questions, checking other sources, discussing and arguing with colleagues and questioning underlying assumptions.
11. One investigation will lead to another - If the topic is truly engaging for your students, one investigation is likely to lead to another.
12. Explore local issues – GLOBE observations provide several perspectives on your local environment. Addressing a local issue may require your students to make other observations. When students realize that they can contribute to their community or interact with scientists directly, it is often a boost to moral and confidence.

GLOBE Outreach

Outreach activities can help promote local interest in and support for your school's GLOBE Program activities. This section includes outreach, ideas, tips on writing a press release and working with the media. These materials are intended to be a starting point.

GLOBE School Outreach Ideas

- Hold a GLOBE Open House and invite local citizens and the media to join students in making scientific measurements and observation. Allow the students to demonstrate how they report the data via the Internet.
- Schedule a school assembly or PTA meeting to recognize the GLOBE teacher and students. Students can make presentations of their data and talk about what they have learned.
- Help the students organize a "GLOBE Speakers Bureau" and seek opportunities to address local business and civic organizations.
- Invite professionals in the environmental, science and technology fields to meet with GLOBE students.
- Have GLOBE students submit articles and photographs to the local newspaper. The local newspaper may want to feature GLOBE students' observations regularly on their education or "kids" page.
- Show the GLOBE video to small groups to help provide the overview of the program or let your students make their own GLOBE video or slide show.

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GLOBE MEASUREMENTS AND THEIR INSTRUMENTS

MEASUREMENT	INSTRUMENT	SKILL LEVEL
ATMOSPHERE / CLIMATE		
• Cloud Cover / Type	Cloud Chart	All
• Precipitation, Liquid	Rain gauge	All
• Precipitation, Solid	Snowboard, Rain gauge Snow depth pole	All
• Precipitation pH	pH indicator paper pH pen, one pH buffer pH meter, three pH buffer	Beginning Intermediate Advanced
• Air Temperature Maximum / Minimum and Current	Maximum / Minimum thermometer, calibration thermometer, instrument shelter	All
HYDROLOGY		
• Transparency Deep water sites only	Secchi Disk, 5m rope	All
• Transparency Surface water	Turbidity tube	All
• Water temperature	Organic liquid filled thermometer	All
• Dissolved Oxygen	Dissolved oxygen kit	Intermediate, Advanced
• Water pH	pH indicator paper pH pen, one pH buffer pH meter, three pH buffer	Beginning Intermediate Advanced
• Electrical Conductivity Fresh Water Sites only	Total dissolved solids tester, calibration solution	All
• Salinity – Brackish and salt Water Sites	Hydrometer, 500ml clear plastic graduated cylinder, organic liquid filled thermometer	All
• Salinity Titration Method – Brackish and Salt Water Sites	Salinity kit	Optional Intermediate, Advanced
• Nitrate	Water nitrate kit	Intermediate, Advanced
• Alkalinity	Water alkalinity kit	Intermediate, Advanced

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SOIL		
• Soil Characterization Field slope, Horizon depth structure, Color, Consistence Texture, Carbonates	Clinometer, Camera Meter Stick, Color Chart Sample Cans, other containers, shovel or Auger	All
• Soil Characterization Lab Bulk density Particle size Soil pH, Fertility	Drying oven 100ml Graduated cylinder 500 ml clear plastic graduated cylinder, hydrometer Thermometer, Dispersing solution, pH paper, Pen or Meter and pH buffer, Soil NPK kit	All
• Soil Moisture	Balance, Meter Stick, Drying Oven, Sample Cans, other soil containers, Auger (depth sampling) 50m tape measure	All
• Gypsum block soil moisture	Soil moisture meter Gypsum blocks, PVC piping	Advanced
• Infiltration	Dual ring infiltro meter	All
• Soil Temperature	Soil Thermometer	All
LAND COVER / BIOLOGY		
• Land Cover Mapping	Remote sensing image, Multispec software	All
• Species Identification	Dichotomous keys	All
• Biometry Tree Circumference Tree Height Canopy Cover Ground Cover	Clinometer and densiometer (both may be student made) 50m tape measure	All
• Biometry, Grass Biomass	Drying oven	All
LOCATION		
Latitude and longitude of study sites	Global Positioning Receiver	All

Chapter II

GLOBAL POSITIONING SYSTEM (GPS)

Overview

A Global Positioning System (GPS) receiver is a hand-held device that receives data directly from overhead satellites. With a GPS receiver, student can determine their location, as measured in latitude and longitude, almost anywhere in the world to accuracy of 10 – 15 meters. As a part of GLOBE we want the students to determine the latitude and longitude of their school as well as of their GLOBE study sites. These data will locate the sites of their biosphere measurements and will be used by scientists and students worldwide.

GPS Satellites

The Global Positioning System consists of a series of satellites, their ground control stations, and users with GPS receivers. These satellites are unmanned and are launched by expendable rockets that place them into orbit. There are 28 GPS satellites in orbits 20,200km above Earth's surface. At this attitude, the satellites take about 12 hours to complete one orbit.

The satellites are placed in their orbits so that at least four are always in view of a terrestrial observer at any point on Earth.

When operating, the GPS unit is able to identify each satellite as they come into view, and evaluate the quality of the incoming signals. Modern GPS units may receive signals from up to 12 satellites at the same time.

A minimum of 3 signals are required to give latitude and longitude, while reception of a minimum four signals is necessary to calculate the altitude.

RECEPTION OF MORE SIGNALS PRODUCES MORE ACCURATE RESULTS.

The capabilities of the GPS System rely critically on the development of extremely accurate atomic clocks. The most accurate clocks are capable of neither loosing nor gaining more than one second in 20 million years. The time given in the GPS receiver is accurate to within one billionth of a second.

How to Perform Your GPS Investigation

Measurement Logistics

Students must determine the latitude, longitude, and elevation of their school, and for all other GLOBE Study Sites. The location and elevation of each site must be determined only once.

Places for GPS measurements

Site	GPS Measurement Location
School	Main entrance
Atmosphere Study Site	Instrument shelter and rain gauge location
Hydrology Study Site	Surface water-sampling location
Land Cover Sample Site	Centre of each 90m × 90m site of homogenous area
Soil Sample Site	
- Soil Characterization Site	Soil profile location
- Soil Moisture Site	Centre of the soil moisture star pattern
- Soil Temperature Site	Soil moisture or atmospheric site location

Frequency

The latitude, longitude and elevation of each study or sample site is determined using GPS technology needs to be performed and submitted only once.

Procedure

Before the measurement

Decide where you wish to perform your measurements. Be aware that obstructions such as tree cover may reduce the satellite signal quality.

During the measurement

- At least two students should take the work sheet and a GPS receiver to your measurement site. One student will operate the instrument while another records the data.

- Press the On / Off button once to turn on the receiver. After an introduction message, the receiver displays previous latitude, longitude, and elevation values while it locks onto the satellite timing signals.
- Wait for the receiver to indicate that at least four satellites have been acquired and that a good measurement is available.
- At one minute intervals and without moving the receiver more than one meter, make 15 recordings on a copy of the Site Location Data Work Sheet of all digits and symbols for the following displayed values.

  a) Latitude c) Time e) Status Icons

  b) Longitude d) Elevation
- Turn off the receiver

After the measurement

- Average all 15 readings of latitudes, longitudes, and elevations.
- Copy and submit all GPS readings as your site location to the GLOBE Student Data Archive.
- Follow this protocol at each site.
  - Express latitude and longitude in decimal degrees.
  - Express time in units of UT hours, minutes, and seconds.
  - Express elevations in meters

Converting from Degrees and Decimal Minutes to Decimal Degrees

1 Degree = 60 minutes

Reading in decimal degree = degrees + decimal minutes/60 minutes/degree

Example

A latitude reading is given as 15 degrees and 39.03 min N

Latitude in decimal degrees = 15 degrees + 39.03 minutes/60 minutes/degree

= 15 degrees + 0.6505 degrees

= 15.6505 degrees

Why GPS Receivers Use Degrees and Minutes

A GPS Receiver is available for you to borrow from GLOBE. It presents longitude and latitude angle measurements in whole degrees and decimal minutes. The decimal minutes are displayed to a resolution of two digits to the right of the minute's decimal point. A typical measurement of latitude may be displayed as 35^0 15.01”.

If we were to display two digits for seconds then our rightmost digit in the seconds would be describing an angle which is larger than the rightmost digit in the 15.01 minutes format thus, the engineers who designed the GPS receiver have presented the angle measurement in a format which displays a smaller angle with the same number of digits displayed.

Averaging Angles Measured in Degrees and Minutes.

Background

To average a series of numbers, you add them together then divide by the number of values added. Thus averaging calls for both addition and division. Convert all 15 values first to decimal degrees, perform the addition and division, then convert the result back to degrees and decimal minutes. Round up the values up to the five digits to the right of the decimal point.

Example: -

Measured Values

Serial Number	Latitude	
	Degrees	**Minutes**
1	40	00.01
2	40	00.02
3	40	00.01
4	40	00.00
5	39	59.99
6	39	59.98
7	39	59.99
8	40	00.00
9	40	00.01
10	40	00.01
11	40	00.00
12	39	59.99
13	39	59.99
14	39	59.99
15	40	00.01

Minutes / 60 Decimal Degrees	Degrees + Minutes / 60 Decimal Degrees
0.00017	40.00017
0.00033	40.00033
0.00000	40.00017
0.99983	40.00000
0.99667	39.99983
0.99983	39.99967
0.00000	39.99983
0.00017	40.00000
0.00017	40.00017
0.00000	40.00017
0.99983	40.00000
0.99983	39.99983
0.99983	39.99983
0.00017	40.00017

For each measurement:

- Dividing minutes by 60
- Add to whole degrees

Average all decimal degree values:

- Add all decimal degree values
- Divide by 15 samples
- Convert back to degrees and minutes

Sum = 600.00000

Sum / 15 = 40.00000 Degrees (Average)

Average = 40 + 0.00000 × 60

Resulting Average Latitude 40 degrees 0.00 minutes

Chapter III

ATMOSPHERIC INVESTIGATION

GLOBE Measurements

What measurements (basic) are taken?

- **Cloud Observation**
  Cloud Cover and Type
- **Contrail Observation**
  Contrail Cover and Type
- **Precipitation and its pH**
  Solid and Liquid
- **Maximum, Minimum and Current Temperature**

Where are measurements taken?

Criteria for Site Selection

Atmospheric Measurements are taken at the Atmospheric Study Site. The Atmospheric study site should be located on or near the school ground so that students can have daily access to them.

The ideal site for taking atmospheric measurements is open, away from trees, buildings, and other structures. Trees, buildings, and other structures are all at least four times as far as they are tall.

Measurements of cloud and contrail amount and type require an unobstructed view of the sky. The middle of a sports field would be an excellent location. The site where you take your cloud measurements does not have to be exact location of your rain gauge and thermometers.

A site is satisfactory if a small portion of the sky is blocked as long as that portion would not change the measurements you report.

The ideal placement for both the rain gauge (and/or snowboard) and the instrument shelter, which will house the thermometer, is a flat open area with a natural (grassy) surface. Avoid building roofs and paved or concrete surfaces if at all possible. Hard surfaces can cause errors in precipitation measurements due to splash in.

Instrument Shelter/ Rain Gauge Placement

The ideal placement for both the rain gauge (and / or snowboard) and the instrument shelter, which will house the thermometers, is a flat, open area with a natural (e.g. Grassy) surface. Avoid building roofs and paved or concrete surfaces if at all possible, these can become hotter than a grassy surface and affect temperature readings.

Do not place the rain gauge and instrument shelter close to the buildings, trees, or high bushes. Nearby objects can block the flow of air to the thermometers and affect the amount of rain that collects in the rain gauge. Ideally the rain gauge and the instrument shelter should be placed four times as far from an object as that object is tall.

The instrument shelter should be mounted so that the maximum/minimum thermometer mounted inside is 1.5 meters above the ground. The instrument shelter should be mounted on the side of the post that faces away from the equator. That is, the instrument shelter should be placed on the north facing side of the post in the northern hemisphere, and on the south facing side of the post in the southern hemisphere.

Your students should draw a map of your locations of the instruments. Include their placement relative to nearby buildings, trees, and shrubs using north-south coordinates as well as their distances to these objects. Information about the relative locations of possible obstructions and about the surface material should be reported to the GLOBE Student Data Server as part of defining your Atmosphere Study Site.

Snowboard Placement

Place the snowboard on relatively level ground where the snow depth best represents the average depth of the surrounding area. For a hillside, use the slope with an exposure away from the sun. The site should be free from trees, buildings, and other obstructions that may affect wind flow or the meeting of snow.

Determine location

Once you have chosen the site for the instrument, determine its coordinates (latitude, longitude and elevation) with the GPS receiver, and submit your findings to the GLOBE Student Data Server.

When are measurements taken?

The GLOBE atmosphere measurements should be made within one hour of local solar noon, and readings of daily total precipitation and maximum and minimum temperature is only acceptable if they are made within this 2-hour time period. Cloud and contrail observations, current temperature measurements are taken within one hour of local solar noon.

How long does it takes to do the measurements?

Measurements	**Approximate time required (in Minutes)**
Cloud and contrail cover and type	10
Precipitation	5 – 10
Precipitation pH using meter including calibration	10
Maximum, minimum and current temperature	5

Local Solar Noon

Local solar noon is the key time for taking GLOBE atmosphere measurements. Solar noon is the term used by GLOBE for the time when the sun appears to have reached its highest point in the sky during the day.

An easy way to determine local solar noon is to find a newspaper from your town that gives times of sunrise and sunset and to calculate the average of these times. First convert both times to 24-hour clock times by adding 12 to any p.m. times, then add the two times and divide by two. This is the solar noon.

Example:	**1**	**2**
Sunrise (am or 24-hour clock are the same)	7:02 am	6:58 am
Sunset	5:43 pm	5:46pm
Sunset (24-hour clock)	17:43	17:46
Sunset + Sunrise	24 hrs 45 min	23 hrs 104 min
Equivalent (so that the number of hrs is even)	Unchanged	24 hrs 44 min
Divide by 2	12 hrs 22.5 min	12 hrs 22 min
Local Solar Noon (rounded to the nearest minute)	12:23 pm	12:22 pm

Atmospheric Protocols

Cloud and Contrail Protocol

1. CLOUD TYPE PROTOCOL

Purpose

To observe the type of clouds at the School's Atmosphere Study Site.

Overview

Cloud type is a qualitative measurement.

Frequency

Daily within one hour of local solar noon.

How to observe cloud type?

From your cloud type observation site, examine the clouds in the sky. Refer to the GLOBE cloud chart and the definitions found on the observing cloud type sheet check a box on the Atmosphere Data Collection sheet for each cloud type that you observe.

In some instance, it may be difficult to distinguish between cloud types (e.g. Altocumulus versus cirrocumulus). In these cases, students should use their best judgement and note their uncertainty in the comment section and in their GLOBE Science Notebook.

Data Submission

Report the following to the GLOBE Students Data Server:

- Date and time of the cloud type observation in Universal Time (UT).
- Cloud types observed at the atmospheric site (you can report more than one cloud type).

2. CLOUD COVER PROTOCOL

Purpose

To observe could cover at the school Atmosphere Study Site.

Overview

Cloud cover is a subjective estimate but an important scientific one. Cloud cover accounts for the amount of solar radiation, which is reflected or absorbed before sunlight reaches Earth's surface and the amount of radiations coming up from the Earth's surface.

Frequency

Daily within one hour of local solar noon

Background

Clouds play a complex role in climate. They are the source of precipitation, affects the amount of energy from the sun that reaches Earth's Surface, and insulate Earth's surface and lower atmosphere.

How to Observe Cloud Cover

Take the cloud cover measurements at the same site and time, as the cloud type measurement. Cloud cover should be reported according to the following cloud-cover classification definitions:

No Clouds

The sky is cloudless; there are no clouds visible.

Clear

Clouds are present but cover less than one-tenth (or 10%) of the sky.

Isolated Clouds

Clouds cover between one-tenth (10%) and one-fourth (255) of the sky.

Scattered Clouds

Clouds cover between one-fourth (25%) and one-half (50%) of the sky.

Broken Clouds

Clouds cover between one-half (50%) and nine-tenth (90%) of the sky.

Overcast

Cloud cover more than nine-tenth (90%) of the sky.

Even experienced observers can have difficulty in accurately differentiating between scattered clouds and broken clouds. If you see more blue sky than clouds, then the cloud cover is considered to be scattered. If you see more clouds than the blue sky, you can say that the cloud cover is broken.
Students can record more than one type of the cloud cover in a given time.

Data Submission

Record on the Atmosphere Investigation Data Work Sheet one of the six categories of cloud cover each day and report your findings to the GLOBE Student Data Server.

OBSERVING, DESCRIBING AND IDENTIFYING CLOUDS

Background

Accurate weather forecasting starts with careful and consistent observation. Recognizing cloud types can help you predict the kind of weather to expect in the near future.

Students Develop a Personal Cloud Booklet

Students should develop, either in their GLOBE Science Notebooks or in separate cloud booklets; an individual personal set of notes on clouds and cloud types. They can include not only their own observations and descriptions but also photographs of clouds that they take or that they clip from other sources. If several types of clouds are present, they should record each of the types on a separate page of their notebook.

Identifying and classifying clouds

The names used for the clouds are based on three factors their shape, the altitude at which they occur and whether they are producing precipitation.

1. Clouds Come In Three Basic Shapes

    - Cumulus Clouds (heaped and puffy)
    - Stratus Clouds (layered)
    - Cirrus Clouds (Wispy)

2. Clouds occur in three altitude ranges (specifically, the altitude of the cloud base)

    - High clouds (above 6000m), designated by "cirrus or cirro"
        - Cirrus
        - Cirrocumulus
        - Cirrostratus
    - Middle clouds (2000-6000m) designated by "alto"
        - Altocumulus
        - Altostratus
    - Low clouds (below 2000m) no prefix
        - Stratus
        - Nimbostratus
        - Cumulus
        - Stratocumulus
        - Cumulonimbus

3. Clouds whose names incorporate the word "nimbus" or the prefix "nimbo" – are clouds from which precipitation is falling.

Cloud Identification Tips

- Clouds that are wispy and high in the sky are always cirrus of one type or another. If the cirrus clouds contain waves or puffs, then they are cirrocumulus. If they form continuous layers that seem to cover the sky high up, they are cirrostratus.

- Clouds at middle altitudes are designated by the prefix "alto". If in layers, they are altostratus, if in heaps and puffy, they are altocumulus.
- Clouds that form at low altitudes (below 2000m) are either cumulus or stratus family. Clouds in the cumulus family are puffy and heaped. Clouds in the stratus family form in layers or sheets that cover broad expanses of sky.
- Low clouds that are dark, threatening and actually producing rain receive the designation "nimbus". Nimbostratus cloud cover the entire sky with broad sheets and produce steady rain. Cumulonimbus have dark bases and puffy tops, they tend to produce heavy precipitation.

3. CONTRAIL TYPE PROTOCOL

What is Contrails?

When the jet aircraft passes through the portion of the atmosphere having just the right combination of moisture and temperature it will form a linear cloud. These are known as Contrails or Condensation trails.

Purpose

To measure the contrail type at the atmospheric Study Site

Frequency

Daily within one hour of local solar noon

How to observe Contrail Type?

Contrails generally occur at high levels like cirro or cirrus clouds. There are three types of contrails for students to classify:

Short Lived

Contrails that disappear shortly and form short line segments in the sky that fade out as the distance away from the airplane that created them increases.

Persistent Non-Spreading

These contrails exist long after the airplane that made them has left the area. They form long straight lines of approximately constant width across the sky.

Persistent Spreading

These contrails also exist long after the airplane that made them has left the area they form long streaks that grow wider and fuzzier as the distance from the plane that caused them increases.

4. CONTRAIL COVER PROTOCOL

Purpose

To measure the contrail cover at the atmospheric Study Site

Frequency

Daily within one hour of local solar noon.

How to observe the Contrail Cover?

Look at the sky in every direction at the atmospheric site. The following type of Contrail cover can be observed:

None

There are no contrails visible.

0 – 10%

Contrails are present but cover less than one-tenth (or 10%)of the sky.

10 – 25 %

Contrails cover between one-tenth (10%) and one-fourth (25%) of the sky.

25 – 50%

Contrails cover between one-fourth (25%) and one-half (50%) of the sky.

> 50%

Contrails cover more than one-half (50%) of the sky.

Precipitation Protocol and its pH

1. RAINFALL PROTOCOL

Purpose

To determine the amount of moisture input to the local environment by measuring rain and snowfall and to measure the pH of precipitation.

Overview

Climate studies and Earth systems studies require accurate, long-term rainfall measurements.

Frequency

Daily within one hour of local solar noon.

Background

Rainfall is defined as the depth of water that crosses a horizontal surface over a given time period. You can determine the rainfall by reading the value in millimeters on the measuring scale that corresponds to the water level.

Rain Gauge: An instrument for measuring Rainfall

A standard rain gauge consist of four parts:

- The funnel, which is attached to the measuring tube.
- The measuring tube, which is a small cylindrical tube having a uniform diameter and a graduated scale located on the side of the tube.
- The overflow tube, which is a large cylindrical tube designed to catch any overflow of rain during periods of heavy rainfall.
- A mounting bracket

Insert the measuring tube into the overflow tube and then insert the funnel into the measuring tube and the overflow tube.

Fasten the mounting bracket to a wood post having a width approximately that of the rain gauge. Fasten so that the top of the rain gauge extends 10cm above the top of the wood post. The mounted and placed rain gauge should be level.

How to Measure Rainfall?

- Once the rain gauge is located properly, it must be read daily within one hour of local solar noon.
- When students read the measuring scale, make sure their eyes are at the level of the water in the measuring tube and that they read the bottom of the meniscus.

- After each measurement, they should empty the water from the measuring tube into the clean beaker or jar for the pH measurement by inverting the tube and allowing it to drain. Then they should reassemble and remount the rain gauge. Record the data of the measurement, the rain gauge. Record the data of the measurement, the UT time of the reading, the depth of rainfall in millimeters, and the number of days the rain has accumulated in the Atmosphere Investigation Data Work Sheet.

During periods of heavy rainfall, the rainwater may exceed the capacity of the measuring tube and flow into the overflow tube. In this case, the level in the measuring tube should be noted and the tube emptied. Then pour the water from the overflow tube into the measuring tube and note the water level. This may have to be done several times in order to empty the overflow tube. The resulting depths should then be summed-up to determine the overall depth of precipitation.

Even if it has not rained, students should check the rain gauge daily to make sure that it is free of debris (windblown leaves, twigs, papers etc). Clean the rain gauge after each reading, rinsing it with distilled water.

Bring the rain gauge indoors when the temperature falls below freezing to prevent the plastic gauge from cracking.

Data Submission

Report the following information to the GLOBE Student Data Server:

- Date and time of day of the data collection (in Universal Time)
- Amount of daily rainfall (in millimeters)
- Number of days rain has accumulated.

For days when there is no rain, place a zero in the rainwater in rain gauge column. On days when water in the rain gauge is accidentally spilled or the measurement is lost for some reason, enter the letter "M" (for missing) for the daily rain amount. It is important that a missing value is recorded rather than a zero (It is common mistake to substitute zeroes for missing values. This leads to erroneous Analysis).

On days when there is rainfall but the amount is less than 0.5mm, enter the letter "T" (for trace) for the daily rain amount. This tells us that extremely light rainfall occurred.

It is important to take daily readings of rainfall. In these cases, report 1 for the number of days rain has accumulated. If it is not possible to read the gauge for several days, you must report the number of days since the gauge was last read or emptied. You must report the number of days even if the reading is zero.

Type of Event	**Report to GLOBE the # of days since your last measurement AND**
No Rainfall	0
Rainfall > 0.5 mm with no problems reading the gauge	The rainfall amount in your rain gauge.
Very small amount of rain < 0.5 mm	T (for Trace)
Spilled rain gauge before measurement could be made; gauge post fell over; etc.	M (for Missing)

2. SOLID PRECIPITATION PROTOCOL

Purpose

To measure solid precipitation at the Atmosphere Study Site.

Overview

Climate studies and Earth System studies require accurate, long-term solid precipitation measurements.

Frequency

Daily within one hour of local solar noon.

Background

A snowboard is a thin, flat surface that rests on top of earlier layers of snow. New snow falls on top of it and can be measured with the measuring stick. The board may be made of thin plywood (1cm or 3/8"). The board should be at least 40 cm in size so that more than one snow depth measurement can be made. Mark the location of the snowboard so that it can be easily located after it has been covered by a new snowboard.

How to Measure Solid Precipitation?

- For your first snowfall, insert the measuring stick vertically into the snow until it rests on the ground surface. Be careful not to mistake on ice layer or crusted snow for the ground. Repeat the measurement in several places where the snow is least affected by drifting. If there is no new snow enter "0". If the measured depth is between 0 and 0.5 millimetres, enter the letter "T" (for trace).

- Place the snowboard on the top of existing snow and push gently into the snow so that its surface is flushed with the snow's surface. Place a flag or other marker nearby to help you locate the snowboard after the next snowfall.
- After a new snow has fallen on earlier snow, gently insert the measuring stick into the snow until it touches the snowboard. Take several measurements at different spots on the snowboard and average these measurements. This will be your depth of new snow on the snowboard.
- Measure total depth of snow on the ground at the same time as daily accumulation. The procedure is the same as for measuring, the first snowfall, insert the measuring stick vertically into the several places and take the average of the depth readings.

Determining Liquid - Water Content of Daily Solid Precipitation

Not all snowfalls are alike. Some are light and fluffy. While others are wet and heavy. Meeting a sample of snow and measuring the volume of the water determine the daily liquid equivalent of solid precipitation. For this measurement a collection container is necessary. When outside temperatures are below freezing, the plastic rain gauges used for liquid precipitation measurement may crack and break, so they should be brought indoors.

1. Once you have measured the depth of daily snowfall on the snowboard, take the large cylinder from the rain gauge and invert it on the snowboard, pushing the cylinder down carefully so that is touches the board's surface. If the depth of snow is greater than the depth of the overflow cylinder, you may compact the snow in the cylinder. If the snow is too deep, you may not be able to compact the snow into the cylinder as a single sample. Depending on the size of your snowboard and the depth of snowfall, there are at least two ways to get that circle of snow into your cylinder.

Method A

If your snowboard is not large or heavy, hold the cylinder against the board and invert both snowboard and cylinder. This will cause the snow outside the cylinder to fall off the board, so be sure you've made your depth measurement first. The snow trapped in the cylinder can now be taken indoors.

Method B

1. If your snowboard is too big or heavy to turn over easily or if the snow column, even compacted, will not fit into the cylinder, you will have to transfer the snow into the cylinder or other container by hand. Carefully lift the cylinder of the board and you should have a nice-circle of snow in the shape of the cylinder. Carefully scoop the snow from within this circle into your cylinder or other container.
2. Once the snow is inside the cylinder or other container, bring it indoors and allow it to melt. Place a cover over the container to prevent evaporation.
3. When the snow has melted, carefully pour the water into the measuring tube of the rain gauge and read the depth of water in the same way you read the rainfall.

It is possible that an overnight snowfall may melt before the daily precipitation measurement is made. If you have left your overflow cylinder outside, you can still report the liquid water equivalent of your snowfall. Enter "M" for daily depth of new snow and 0.0mm for total depth of snow on the ground. If you have measured the depth of snow before it melted, this could also be reported under comments, along with the time you made the measurements.

Setting Up for the Next Measurement

After you have completed your snow observation clean the snowboard and again flush on the snow's surface.

Data Submission

Report the following information to the GLOBE Student Data Server:

- Data and time of data collection (in Universal Time)
- Total depth of snow on the ground (mm)
- Daily depth of new snow (mm)
- Number of days snow has accumulated on the snow board
- The depth of water from the melted snow on the snowboard (mm)

If snow has fallen but for some reason, measurements cannot be taken then enter the letter “M” (for missing). If the snowfall has not been measured for several days enter the number of days since the snowboard was last cleared along with the amount of snowfall.

3. PRECIPITATION pH PROTOCOL

Purpose

To measure pH of rain and snow

Overview

The pH of precipitation affects the region on which it falls. Acidic precipitation can affect vegetation, buildings, and statues. The pH of precipitation can also change the pH of water in surface water bodies or in the soil.

Frequency

For rainfall: Whenever you have accumulated at least 2mm of rainfall in your rain gauge.

For snowfall: Whenever there has been enough new snow fall such that you can collect snow which has not been in direct contact with the ground or with your snowboard and this snow, when melted, produces at least 20ml of liquid.

How to measure pH of the Rainfall?

Beginning Students: pH Indicator Paper

1. Use a clean, dry 100ml beaker.
2. After reading and recording the amount of rainfall in your rain gauge, if there has been at least 2mm of accumulated rainfall, pour the rainwater into the beaker. If there has been a large amount of rainfall, you need to fill the beaker about half full with the rainwater.
3. Dip one strip of pH indicator paper into the rainwater in the beaker and hold it there for about 20 seconds. Make sure all of the colored segments of the paper are immersed in the rainwater.

4. Remove the paper from the water and compare the resultant color segments with the chart on the pH indicator paper box. Try to find a sequence where all color segments on the paper match all segments on one of the stripes on the box.
5. If the reading is unclear, the paper may need more time to fully react. Place the paper back in the rainwater in the beaker for an additional 20 seconds, then repeat steps 4 and 5. Repeat until you are satisfied that the reading is accurate. If after 2 minutes, the reading is still unclear, start all over with new strips of paper. If the tests fail a second time, indicate this on your Atmosphere Investigation Data Worksheet.
6. Report your measured pH to the GLOBE Student Data Server.
7. Regardless of whether or not it has rained, your rain gauge must be roughly scrubbed using distilled water and dried at least once per weak. Any foreign material in your rain gauge can affect your pH reading.

Do not use soap or detergents in your rain gauge as residues can affect your pH reading.

Intermediate / Advanced: pH pen / pH meter

STEP I: CONDITIONING AND CALIBRATION OF THE pH PEN OR METER

Step a: Prepare the Buffer Solutions

Pre mixed buffer solutions can be stored for 1 year, as long as they have not been contaminated. If you are using the powdered pillow buffer, then dissolve it in distilled water as described below. If you are using pre-mixed buffer solution measure 50 ml into a graduated cylinder and proceed to step 4.

For each pH buffer (4, 7 and 10)

1. Write the buffer pH and date on two pieces of masking tape. Place one on a clean, dry 100ml beaker, and the other on a 50ml bottle.

2. Using a graduated cylinder, measure 50ml of distilled water and pour it into the beaker.
3. Over the beaker, completely cut open one end of a pillow of buffer powder, then squeeze and shake the pillow to release the powder into the water. Make sure all the powder is released into the water. Stir with stirring rod until all the powder dissolves.
4. Pour the buffer solution into the labelled bottle. Cap the bottle tightly. Discard after a month.
5. Continue preparing the other buffers, repeating steps 1-4 for each.

Step b. Calibrate the pH pen or meter

i) Calibration of the pH pen

If the pH pen does not have automatic temperature compensation, the buffer solution should be at 25^{0}C.

1. Condition the electrode glass probe as described by manufacturer.
2. Rinse the electrode and area around it twice with distilled water using a squeeze bottle and blot dry with a soft tissues after each rinse. Rinse into a discard beaker or sink, not into pH buffer solution and do not touch the electrode with your fingers.
3. Turn the pen on with the switch on top, and then immerse the electrode entirely in the pH 7.0 buffer solutions.
4. Gently stir the buffer solution with the probe and wait for the reading to stabilize.
5. Use a jewellery screwdriver to turn the small screw in the hole in the back of the pen until the reading is exactly 7.0.
6. Remove the pH pen from the solution and rinse the electrode with distilled water pour the buffer solution back into its labelled bottle and seal tightly.

ii) Calibration of the pH meter

1. Condition the electrode as described in the manufacturer's instructions.
2. Rinse the electrode and area around it twice with distilled water using a squeeze bottle and blot dry with a soft tissue after each rinse. Rinse into a

discord beaker or sink, not into the pH buffer solution and do not touch the electrode with your fingers.

3. Turn the meter on (by pressing the ON/OFF button). Push the CAL button to indicate that you will be calibrating the instrument.
4. Immerse the electrode in the pH 7.0 buffer solution making sure that electrode is entirely immersed.
5. Gently stir the buffer solution with the electrode and wait for the display value to stabilize. Once the reading has stabilized press the HOLD/ON button to accept the value and complete the calibration. If the electrode is still immersed in the buffer the display will read the same values as the pH of the buffer (i.e. 4 , 7 or 10).
6. Remove the pH tester from the buffer solution, rinse the electrode with distilled water, and blot dry with soft tissue.
7. Repeat steps 3 to 6 using the pH 4 buffers and then using the pH 10 buffers.
8. Set the tester aside on a paper towel; turn the meter off by pushing the ON/OFF button.
9. Pour the buffer solution into their labelled bottles and cap them tightly.

STEP II: MEASURING THE pH OF THE COLLECTED RAINFALL

Take your calibrated pH pen or meter and a clean dry beaker with you to your rain gauge site and make your pH reading immediately after reading the rainfall amount.

1. Prior to leaving the classroom, remove the cap and rinse the electrode and the surrounding area of your pH pen or meter with distilled water. Blot the area dry with a soft tissue.
2. Obtain a clean, dry 100ml or larger beaker and take it as well as your pH pen or meter, with you to the rain gauge site.
3. At the rain gauge read and record the amount of rainfall.
4. If there is at least 2mm of rainfall in your gauge, pour the rainwater into the beaker. If there has been a large amount of rainfall you need only fill the beaker about half full with rainwater.
5. Immerse the electrode of your pH pen or meter in the beaker containing the water. Be sure that the entire electrode is immersed. If you do not have

enough rainwater to completely immerse the electrode, do not make a rainfall pH measurement.

6. Stir the rainwater once with the pH pen or meter and then let the display value stabilize.
7. Read the pH value and record it on the Atmosphere Investigation Data Work Sheet.
8. The two pH values should agree to within 0.2, if they do not make a third measurement with a new sample of rainwater.
9. If you had enough rainwater to make three or more pH measurements, take the average of the pH values measured. If all recorded values are within 0.2 of this average.
10. Report this average value to the Data Server.
11. Rinse the pH pen or meter with distilled water, blot it dry with soft tissue, replace the cap on the probe, and turn off the instrument.

How to measure pH of Snowfall?

Collection of Snow for pH Measurement

When you are going to measure snow pH, you will need to gather a second sample of snow in addition to the sample gathered to determine liquid water equivalent. For the pH snow sample you want to also take a core of snow from the snowboard. In order to obtain enough snow to produce at least 20ml of water once the snow melts; you collect several cores from other locations on your snowboard.

Any clean, dry, deep container (glass or plastic) can be used to collect the snow sample for the pH measurement once you have collected the snow, take the container inside, and cover it. Let the snow melt at room temperature.

When the snow has melted you are ready to make your pH measurement as described in the sections above using the melted snow instead of the rain water and taking the measurement in the classroom instead of at the Atmosphere Study Site.

Maximum, Minimum and Current Temperatures Protocol

Purpose

To measure air temperature at the Atmosphere Study Site

Overview

Climate studies and Earth System Studies require accurate, long-term air temperature measurements.

Frequency

Daily within one hour of local solar noon.

Background

The liquid filled maximum/minimum thermometer is a horseshoe-shaped tube with two indicators that indicate the maximum and minimum temperatures. On the maximum side, the temperature scale is such that temperature increases as you go from bottom to top. On the minimum side, the scale shows temperature decreasing as you go from bottom to top. As the temperature increases, the expansion of the liquid in the bulb pushes the mercury down on the minimum side and up on the maximum side. The indicator at the top of the mercury column on the maximum side of the thermometer is pushed upward. When the temperature drops, the column of mercury moves in the opposite direction, but the indicator on the maximum side remains in place indicating the highest temperature reached. As the temperature decreases, the mercury column rises on the minimum side of the thermometer until it reaches the indicator pin on the minimum side. Then if, the temperature continues to decrease, it pushes this indicator upward. When the temperature again increases, the indicator on the minimum side remains in place to indicate the lowest temperature reached.

The students should read the maximum and minimum temperature at the bottom of the indicators.

Calibration of Thermometer

Your maximum / minimum thermometer should be calibrated upon installation and again every six months after installation (more frequent calibration may be required if you find the current temperature does not read the same on both scales or if at some point, the mercury column becomes discontinuous and needs to be fixed).

To calibrate the maximum/minimum thermometer, you should compare it with a calibration thermometer. The calibration thermometer that can record temperatures at least as low as -5^0C. The calibration thermometer itself must first be tested for accuracy by placing it in an ice-water bath.

- Prepare a mixture of one part liquid water to one part crushed ice.
- Allow the ice-water bath to sit for 10-15 minutes so it reaches its lowest temperature.
- The bulb of your calibration thermometer should then be placed in the bath. Gently move the thermometer around in the ice water bath so that it will be thoroughly cooled. The thermometer should read between 0.0 and 0.5^0C. If it does not, use another thermometer.
- Once you are confident of the accuracy of your calibration thermometer, leave it by a look in the instrument shelter.
- After 24 hours, compare the temperatures on both thermometers. If they differ, the maximum/minimum thermometer should be calibrated to the temperature of the calibration thermometer. Adjust the temperature of scales on both sides of the thermometer by loosening the small screw located in the back of the thermometer. Once this screw is loosened, the scales can slide up or down independently of each other.

Placement of the Maximum / Minimum Thermometer

Mount the maximum / minimum thermometer in the instrument shelter so that there is air flow all around the thermometer case. The thermometer should be attached to blocks on the rear wall of the shelter so that no part of it touches the walls, floor, or ceiling of the shelter. The thermometer must be 1.5 meters above the ground or 0.6 meters above the average maximum snow depth whichever is higher. The shelter protects the thermometer from radiation from the sun, sky, ground, and surrounding objects, but allows air to flow through so the air temperature inside the shelter is the same as the air temperature outside the shelter.

The instrument shelter should be mounted on a post that is secured in the ground as firmly as possible so as to eliminate vibrations caused by strong winds. The shelter's door should face north in the Northern hemisphere and south in the southern hemisphere to reduce exposure of the thermometer to direct sunlight when the door is open for the daily measurement.

Instrument shelter should be constructed using the plan in the toolkit.

How to Measure Air Temperature?

- Assign a team of students to read the thermometer daily within one hour of local solar noon. They should stand as far from the thermometers as possible to prevent body heat from changing the temperature reading. Do not touch or breath on the temperature sensing parts of the thermometer.
- Students should read the current daily temperature at the top to the column of mercury on either the maximum or minimum sides of the U-tube thermometer. Make sure that their eyes are level with the top of the mercury column.
- Take the maximum and minimum readings at the base of the indicators.
- Once the maximum, minimum, and current temperatures are read, students should reset the indicators. This is done by using a small magnet to drag the indicators down until they are on top of the mercury column. To avoid losing the magnet, attach it either to the shelter or to the thermometer with the piece of string.

Data Submission

Report the following data to the GLOBE Student Data Server

- Date and time of the data collection in Universal Time
- Current air temperature
- Maximum daily air temperature
- Minimum daily air temperature

BUILDING A THERMOMETER

Purpose

To help students understand why and how a standard thermometer works.

Overview

Students will construct a soda bottle thermometer, which is similar to the thermometer used by GLOBE schools. Both are based on the principle that most substances expand and contract as their temperature changes. This experiment also demonstrates the principal of heat transfer.

Background

Several scientific principles work in this activity. One is the principle of expansion and contraction most substances expand when heated and contract when cooled. Over the range of temperature in this experiment water too expands when heated and contract when cooled as water approaches its freezing point, it again expands.

Substances expand when heated because their kinetic energy increases with temperature. The molecules move faster and spread further apart causing the material to expand. When the substances are cooled, molecular movement decreases and the substance contracts.

In the case of water, the coefficient of expansion is quite small, so the volume of the water increases by only a very small percentage. Nonetheless, because all the increase in volume is channeled into the small climate straw, the expansion can be seen.

This experiment also illustrates heat transfer by conduction. Conduction occurs when energy is transferred from one molecule to the next by direct contact, such as when the metal handle of a pan becomes hot. In this experiment, the warm water in the outer container transfers the heat by conduction through the plastic wall of one liter bottle to the water in the inner bottle although heat transfer by conduction. Conduction can take place in solids, liquids and gases it is most efficient in solids and liquids. In the atmosphere the air molecules in contact with the ground are heated by conduction.

Convection is the large-scale movement of a liquid or a gas, which acts to redistribute heat throughout the entire volume. A common example of convection is water boiling in a pot. In this case, the water in contact with the bottom of the pot becomes heated and less dense than the water on top of it.

What to do and how to do it

Building the Thermometer

- Fill the 1 litter soda bottle to the very top of the lip with the cold top water.

- Add four drops of food colouring. This makes the water line easier to see.
- Roll some modelling clay into a small ball of about 25mm in diameter. Then roll it out so that it forms a cylinder about the length and diameter of a pencil. Flatten the pencil-shaped clay into a thick ribbon. Wrap the ribbon around the mid point of the straw.
- Place the straw into the bottle and use the clay to seal off the bottle. Be careful not to pinch the straw closed. You also do not want any holes or cracks in the clay that would allow water to escape. One half of the straw will be inside the bottle and one half will be outside the bottle. Press the clay plug into the neck of the bottle far enough to force the water level up into the straw so that it can be seen.

Experiment

- Place the filled one litre bottle into one-litre plastic bottle container. Place a mark on the straw where you see the water line.
- Fill the 2-litre container with hot tap water. Wait for two minutes. Mark the straw at the water line repeat this marking every two minutes, for ten minutes. At the end of the ten minutes, use a ruler to measure the distance of each mark from the original watermark at the bottom of the straw. Record your measurements on the team data sheet.

Team Data Sheet Measurements in Millimeters

2 minutes	
4 minutes	
6 minutes	
8 minutes	
10 minutes	

- Put ice and cold water into the second 2-litre container.
- Place the thermometer bottle into the ice water. Record your observation.
- What happens to the water level in the straw when the thermometer is placed in hot water? What happens to the water level when the thermometer is placed in cold water?

- Explain why you think this is happening.
- Graph the measurement that you recorded on your team data sheet. The x-axis (horizontal) should be the time (in minutes) and the y-axis (vertical) should be your measurements from the original line before the hot water is added (in millimeters).
- Explain the graph. Can you draw any conclusion?
- Students should write the answers to all their questions.
- Teachers should check the answer and make necessary corrections and explain the answers to all the students.

LAND, WATER, AND AIR

Purpose

To help students understand that land and water heat and cool at different rates and that the properties of soil and water influence the heating of air above them.

Overview

Students measure temperature changes in soil, water and air as they are exposed to the heating action of the sun.

Materials and tools

Two plastic buckets at least 30cm tall, a centimetre ruler, six thermometers, a string to suspend the thermometers over the bucket.

Background

One of the important reasons why we have different kinds of weather throughout the world is because land and water heat and cool at different rates e.g. afternoon thunderstorms in Florida are often initiated by the fact that during the day the land heats up faster than the water does. In parts of the world that experience monsoons, the rainy part of the monsoon is characterized by alternating periods of active (rainy) and non-active (non-rainy) weather, depending on whether the land is dry or wet.

Students can study this land / water differences with a simple experiment.

What to Do and How to Do it

- Fill one bucket with soil to a depth of approximately 15 centimetres.
- Fill the other bucket to the same depth with cool water.
- Set both buckets out in the sun. In each bucket suspend a thermometer one cm above, one cm below and eight cm below the surface
- Try to position the thermometers so that the sunlight is not shining directly on the bulb or the glass tube.
- Allow time for the thermometer temperature to stabilize.
- Record the initial thermometer reading.
- Read the temperature of each thermometer at two-minute intervals for 20 minutes. Then read the temperature at one, two, three hours.

Questions for Discussion

Is the temperature of the soil one cm below the surface warmer than it was when students sets out the buckets three hours ago? Is the surface temperature of the water warmer now than it was three hours ago?

Which temperature reading is higher at a depth of 8cm that of the soil or that of the water? What conclusions can students draw from this experiment?

Liquid water molecule moves much more freely than the molecules that make up soil. Therefore water can distribute heat throughout a greater volume than soil can. That is why, after three hours in the sun, the water is the bucket was warmer at the 8-cm depth than was the soil. After sunset, the heat absorbed by soil quickly escapes to the atmosphere and the land cools rapidly. However although water heats up more slowly than land, once it is heated it takes longer to cool.

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Chapter IV

SOIL INVESTIGATION

GLOBE Measurements

What measurements (basic) are taken?

- **Soil Characterization**
  Describes the physical and chemical characteristics of each horizon in a soil profile.
- **Soil Moisture and Temperature**
  Measure the water and temperature properties of soil at specific depths.

Soil Characterization Measurements

Carried out in the field

- Site description
- Horizon Depths
- Soil Structure
- Soil Colour
- Soil Consistence
- Soil Texture
- Roots and Rocks
- Carbonates

Carried out in the Classroom or Lab

- Bulk Density
- Particle Density
- pH

Soil Moisture and Temperature Measurements

Carried out in the field

- Soil Temperature
- Soil Moisture Monitoring

Carried out in the Classroom or Lab

- Soil Moisture

For Lab measurements, use samples collected in the field.

Where are measurements taken?

Soil Study sites for carrying out soil characterization measurements and soil moisture and Soil temperature measurements should be selected carefully.

Options for a Soil Characterization Sample Site

There are four options for exposing the soil at the Soil Characterization Site:

1. Pit Method:
Students dig a soil pit at least 1 meter deep and as big around as is necessary to easily observe all of the soil horizons from the bottom to the top of the pit.

2. Auger Method
Students use a soil auger or probe to remove soil samples to a depth of 1 meter.

3. Near Surface Method
Students use a garden trowel or shovel to collect sample. Students dig to a depth of at least 10 cm. If deeper digging is possible, students should dig up to 1 m.

Study Site for Soil Characterization Measurements

Site should be considered, that allow students to dig a hole with either shovel or auger. The purpose is to expose a soil profile that is one meter deep.

Features of Soil Characterization Sample Site

- The site needs to be safe for digging.
- A site should be chosen that looks similar to the rest of the landscape and, if possible, is covered with natural vegetation.
- The site chosen should be relatively undisturbed. It should be at least 3 meters from buildings, roads, paths, playing fields, or other places where soils may have been compacted or disturbed by construction
- The site should be oriented so that the sun shines on the soil profile at the time students carry out the soil characterization measurements to ensure that the soil characteristics are clear.

Study Site for Soil Moisture Measurements

Site should be in open with no canopy. If possible, the site should be within 100 m of a GLOBE Atmosphere Study Site or other location where precipitation measurements are being collected.

Features of Soil Moisture Sample Site

- Site should be in open.
- Site should not be irrigated.
- Site should have uniform soil characteristics
- Site should be relatively undisturbed and
- Site should be safe for digging.

Study Site for Soil Temperature Measurement

A site should be selected that is adjacent to a GLOBE Atmospheric Study Site, or some other location where air temperatures are taken. Alternatively soil temperature can be measured at a soil moisture study site.

Features for Soil Moisture Study Site

- Site should be open.
- Site should be the representative of the soils in that area.
- Site should be irrigated.

Site Description

The students use the following identifying factors to define and describe the location: -

1. Latitude, longitude and elevation
2. Type of vegetation covering the soil
3. Parent material
4. Current land use practices
5. Position of the soil on the landscape.

When are measurements taken?

Soil characterization measurements should be carried out one time for a soil characterization study site.

To study local changes, soil moisture measurements should be taken twelve or more times per year for the same site at weekly or monthly intervals.

Soil temperature measurements are carried out at least once each week.

How to Expose and Identify Soil Horizons

Soil Pit Technique

- Identify a location where you can dig a soil pit.
- Dig a pit one-meter deep and as big around as is necessary to easily observe all of the soil horizons from the bottom to the top of the pit.
- As soil is removed from the pit, place it carefully on a tarp in piles representing each of the natural layers of the profile.
- Starting from the top of the profile and moving down to the bottom observe the soil profile closely to identify where there are changes in the appearance of the soil face.
- Look carefully for any distinguishing characteristics like different colors, roots, the size and amount of stones, small light or dark nodules, worms or other small animals and insects.
- Mark the location of each of these changes or boundaries by sticking a nail or other marker into the soil.
- Measure the top and bottom depths for each horizon to the nearest cm and record them.
- Proceed to characterize the properties of each of the soil horizons identified. Perform this characterization as soon as possible after the pit is dug.
- Once this protocol is completed, students should fill in the pit with the original soil.

Auger Technique

With this technique, students display the vertical soil profile on a horizontal surface. Be sure to use the correct auger for your site. A Dutch auger is best for most soil.

- Identify a location where an auger can be used to expose a soil profile.
- Spread a plastic sheet tarp, board on the ground next to where you will dig your first hole and where the sun will shine on the profile.
- Remove the surface vegetation.

- Assemble a profile of the top 1-meter of the soil by removing successive samples from the ground with the auger and laying them end-to-end as described follows: -
    - Place the auger at the top of the soil and turn the auger one complete revolution (360) to dig into the ground.
    - Remove the auger with the sample in it from the hole and hold the auger over the plastic sheet.
    - Transfer the sample from the auger to the plastic sheet tarp or board as gently as possible. Place the top of this sample just below the bottom of the previous sample.
    - Measure the depth of the hole. Adjust the sample on the plastic bag, tarp, or board so that its bottom is on further from the top of the soil profile than this depth.
    - Starting from the top and moving down to the bottom, observe the soil profile closely to identify where there are changes in the appearance of the soil.
- Look carefully for any distinguishing characteristics like different colours, roots, the size and number of stones, small light or dark nodules, worms or other small animals and insects.
- Measure the top and bottom depths for each horizon to the nearest cm and record the value.

Near Surface Sample Technique

- In situations where it is not possible for you to expose the top meter of soil, an additional option is to use the top 10-cm of the soil as a single horizon sample for soil characterization.
- Identify a location where the surface of the soil can be exposed.
- Remove the surface vegetation.
- Use a garden trowel or shovel to carefully remove the top 10cm of the soil from a small area and set it on the ground.
- Treat this sample as a horizon and proceed to characterize its properties.

Soil Protocols

Soil Characterization Protocol: Field Measurements

Purpose

To characterize the physical and chemical properties for each horizon in a soil profile and prepare samples for further analysis.

Overview

Students identify the horizons of a soil profile at a soil characterization site, then measure and record the top and bottom depth for each horizon. For each horizon students describe the structure, colour, consistency, texture, and abundance of roots, rocks, and carbonates. Samples are collected and prepared for additional laboratory.

Frequency

Soil Characterization measurements are taken one time for a specific soil site.

1. SOIL STRUCTURE

- Structure refers to the natural shape of aggregates of soil particles, called ped, in the soil.
- The soil structure provides information about the size and shape of pore space in the soil through which water, and airflow, and in which plant roots grow.

How to observe Soil Structure?

1. Use a trowel or other digging device to remove a sample of soil from the horizon being studied.
2. Hold the sample gently in your hand and look closely at the soil to examine its structure.
3. Come to a consensus with other students in a group on the type of soil structure of the horizon. Possible choices of soil structure are:

With Structure:

- ***Granular:*** Resembles cookies and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.
- ***Blocky:*** Irregular blocks that are usually 1.5 – 5.0 cm in diameter.
- ***Prismatic:*** Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.
- ***Columnar:*** Vertical columns of soil that have a white, rounded salt "cap" at the top. Found in arid climates.
- ***Platy:*** Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.

Without structure:

- ***Single Grained:*** soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.
- ***Massive:*** Soil has no visible structure, is hard to break apart and appears in very large clods.

4. Record the structure type on the Soil Characterization Data Sheet.

2. SOIL COLOUR

- The colour of soil is determined by the chemical coating on soil particles, the amount of organic matter in the soil, and the moisture content of the soil.

For example:
Soil colour tends to be darker when organic matter is present.
Minerals, such as iron, can create shades of red and yellow on the surface of soil particles.
Soil in dry areas may appear white due to coatings of calcium carbonates on the soil particles.

- Soil colour is also affected by moisture content. Typically, the greater the moisture contents of a soil, the darker its colour.

How to measure soil main colour and second colour?

1. Take a ped from the horizon being studied and note whether it is moist, dry, or wet. If it is dry, moisture it slightly with water from your water bottle.
2. Break the ped and hold it next to the colour chart.
3. Stand with the sun over your shoulder so that sunlight shines on the colour chart and the soil sample you are examining.
4. Find the colour on the colour chart that most closely matches the colour of the inside surface of the ped. Be sure that students agree on the choice of colour.
5. Record on the Soil Characterization Data Sheet the symbol of the colour that cover the largest area of the ped (dominant or main colour). Sometimes, a soil sample may have more than one colour. Record a maximum of two colours if necessary, and indicate (1) the dominant (main) colour, and (2) the sub-dominant (second) colour.

3. SOIL CONSISTENCE

- Consistence describes the firmness of the individual peds and the degree to which they break apart.
- A soil with firm consistence will be harder for roots, shovel, or plows to move through than a soil with friable consistence.

How to measure soil consistence?

1. Take a ped from the soil horizon being studied. If the soil is very dry, moisten the face of the profile by squirting water on it, and then remove a ped for determining consistence.
2. Holding the ped between your thumb and forefinger, gently squeeze it until it pops or falls apart.
3. Record one of the following categories of soil ped consistence on the Soil Characterization Data Sheet.

Loose:
You have trouble picking out a single ped and the structure falls apart before you handle it.
Note: Soil with single grained structure always have loose consistence.

Friable:
The ped breaks with a small amount of pressure.

Firm:
The ped breaks when you apply a good amount of pressure and the ped dents your fingers before it breaks.

Extremely Firm
The ped can't be crushed with your fingers (you need a hammer!).

4. SOIL TEXTURE

- The texture describes how a soil feels and is determined by the amount of sand, silt and clay particles present in a soil sample.
- The soil texture influences how much water, heat and nutrients will be stored in the soil profile.
- Human hands are sensitive to the difference in size of soil particles.
- Sand is the largest particle: 2.00 – 0.05 mm

  Silt is the next particle size: 0.05 – 0.002 mm

  Clay is the smallest particle: < 0.002 mm

How to measure soil Texture?

Step 1

1. Place some soil from a horizon (about the size of a small egg) in your hand and use the spray mist bottle to moisten the soil. Let the water soak into the soil and then work it between your fingers until it is thoroughly moist. Once the soil is moist, try to form a ball.
2. If the soil forms a ball, go to Step 2. If the soil does not form a ball, call it a sand. Soil texture is complete. Record the texture onto the Soil Characterization Data Sheet.

Step 2

3. Place the ball of soil between your thumb and index finger, gently push, and squeeze it into ribbon. If you can make a ribbon that is longer than 2.5 cm, go to Step 3. if the ribbon breaks apart before it reaches 2.5 cm, call it loamy sand. Soil texture is complete. Record the texture onto the Soil Characterization Data Sheet.

Step 3

4. If the soil:
   - Is very sticky
   - Hard to squeeze
   - Stains your hands
   - Has a shine when rubbed
   - Form a long ribbon (5+) without breaking

   Call it a clay and go to step 4.
   Otherwise, if the soil:
   - Is somewhat sticky
   - Is somewhat hard to squeeze
   - Forms a medium ribbon (between 2 – 5 cm)

   Call it a clay loam and go to step 4.
   Otherwise, if the soil is:
   - Smooth
   - Easy to squeeze
   - At most slightly sticky

- Forms a short ribbon (less than 2 cm)

Call it a loam and go to step 4.

Step 4

5. Wet a small pinch of the soil in your palm and rub it with your forefinger. If the soil:
   - Feels very gritty every time you squeeze the soil, go to A.
   - Feels very smooth, with no gritty feeling, go to B.
   - Feels only a little gritty, go to C.

A. Add the word sandy to the initial classification.

Soil texture is either:

- sandy clay,
- sandy clay loam, or
- sandy loam

Soil texture is complete. Record the texture onto the Soil Characterization Data Sheet.

B. Add the word silt or silty to the initial classification.

Soil texture is either:

- silty clay,
- silty clay loam, or
- silt loam

Soil texture is complete. Record the texture onto the Soil Characterization Data Sheet.

C. Leave the original classification

Soil texture is either:

- clay, clay loam, or loam

Soil texture is complete. Record the texture onto the Soil Characterization Data Sheet.

5. ROOTS

- An estimate of the roots in each horizon in a soil profile illustrates the depth to which roots go to obtain nutrients and water.
- The more roots found in a horizon, the more water and nutrients being removed from the soil, and the more organic matter being returned.

- Scientist estimates the soil's fertility, bulk density, water holding capacity and its depth by knowing the amount of roots present.

How to measure Roots?

1. Observe if there are none, few, or many roots in each horizon.
2. Record your observation on the Soil Characterization Data Sheet.

6. ROCKS

- An estimate of the number of rocks in each horizon helps to understand the movement of water, heat, and air through the soil, root growth, and the amount of soil material involved in physical and chemical reactions.

How to measure rocks?

1. Observe and record if there are none, few or many rocks or rock fragments in the horizon. A rock or rock fragment is defined as being larger than 2 mm in size.
2. Record your observation on the Soil Characterization Data Sheet.

7. SOIL CARBONATES

- Carbonates are usually white in colour and can be scratched easily with a fingernail.
- The presence of carbonates in soil may indicate a dry climate or a particular type of parent material rich in calcium, such as limestone.
- Free carbonates often coat soil particles in soil that are basic (i.e. pH greater than 7).

How to measure Soil Carbonates?

1. Set aside a portion of the pit exposed soil face or sample from the auger hole or near surface which you do not touch with your hands, and use it for the free carbonates test.
2. Open the acid bottle and starting from the bottom of the profile and moving up squirt vinegar on the soil particles.
3. Look carefully for the presence of effervescence. The more carbonates that are present, the more bubbles (effervescence) you will observe.

4. Record on the Soil Characterization Data Sheet one of the following as the results of the Free Carbonates for each horizon:

   - **None**

     If you observe no reaction, the soil has no free carbonates present.

   - **Slight**

     If you observe a very slight bubbling action; this indicates the presence of some carbonates.

   - **Strong**

     If there is a strong reaction (many, large bubbles) this indicates that many carbonates are present.

Soil Characterization Protocol: Lab Measurements

1. SOIL pH PROTOCOL

Purpose
To measure the pH of a soil horizon.

Overview
Students mix dried and sieved soil samples with distilled water. The mixture is allowed to settle until a relatively clear supernatant is formed.

Frequency
Once for each soil horizon.

How to measure pH?

1. In a cup or beaker, measure the pH of the distilled water you will be using. Dip the pH paper or calibrated meter into the water and obtain a reading. Record this on your pH data Sheet.
2. In a cup or beaker, mix dried and sieved soil with distilled water in a 1:1 soil to water ratio (e.g. mix 40g of soil with 40ml of distilled water).
3. Stir the soil/water with a stirrer until it is thoroughly mixed. Stir the soil/water mixture for 30 seconds and then wait for three minutes for a total of five stirring/waiting cycles. Then allow the mixture to settle until a supernatant forms.

4. Measure the pH of the supernatant using the pH paper or meter. Dip the paper or calibrated pH meter in the supernatant. Record the pH value on the Soil pH Data Sheet.
5. Repeat steps 2 – 4 for two more samples from the same location.

2. BULK DENSITY PROTOCOL

Purpose

To measure the bulk density of each horizon in a soil profile.

Overview

In the field, students collect three soil samples from each horizon in a soil profile using a soil container with a measured volume. In a classroom, students weigh the samples, dry them, and weigh them again to determine their dry mass and water content. Students then sieve the dry soil samples and measure the mass and volume of any rocks and material with dimensions greater than 2 mm.

Frequency

Once for a soil profile.

How to measure Bulk Density?

In the classroom before sampling

1. Collect required equipments.
2. Calibrate the balance to 0.1 g.
3. Measure the mass and volume of each can without the lid on and record these measurements onto the Bulk Density data Sheet.
4. Label each can with a number.
5. Punch a small hole into the bottom of each can using the nail and hammer.

In the field

1. For each horizon in your soil profile, push a can into the side of the horizon. If necessary, wet the soil first in order to ease the can into the soil.

- Choose three locations to where Soil characterization Protocol was measured. Remove vegetation and other material from the soil surface.
- At each location, push a can with a known volume into the surface of the soil.

2. Using a trowel or shovel, dig around the can to remove it and the surrounding soil. Trim the soil from the top and around the edges of the can so that the volume of the soil is the same as the volume of the can.
3. Cover the labeled can with its lid or other cover.
4. Repeat the procedure so that you have three bulk density samples for each horizon in your profile.

In the classroom after sampling

1. Remove the lid of the can. Weigh each sample in its can, and record this as the wet mass on the Bulk Density Data Sheet.
2. Dry the samples in a soil-drying oven.
3. After the Soils have dried, weigh each sample in its container and record this as the dry mass on the Bulk Density Data Sheet.
4. Hold a sieve (# 10, 2 mm mesh) over a paper plate or large piece of paper (such as newspaper) and pour one sample onto the sieve. Put on rubber gloves to avoid contaminating your sample with acids from your skin.
5. Carefully push the dried soil material through the mesh onto the paper plate. Be careful not to bend the wire mesh by forcing the soil through. Rocks will stay on top of the sieve. If no sieved soil from each sample for the other lab analyses.
6. If rocks are present, use the following procedure to determine the mass and volume of the rocks.
   - Weigh the rocks and record the mass on the Bulk Density Data Sheet.
   - Place 30 ml of water in a 100 ml graduated cylinder. Record this volume of water on the Bulk Density Data Sheet. Gently place the rocks in the water. Read the level of the water after all the rocks have been added. Record this volume of water on the Bulk Density Data Sheet.

7. Transfer the rock-free dry soil from the paper under the sieve to clean dry plastic bags or containers.

$$\text{Bulk Density (g/ml or g/cm}^3\text{)} = \frac{\text{Mass of dry soil (g)} - \text{Mass of Rocks (g)}}{\text{Volume of dry soil (ml)} - \text{Volume of Rocks (ml)}}$$

SOIL PARTICLE SIZE DISTRIBUTION PROTOCOL

Purpose

To measure the distribution of different sizes of soil particles in each horizon of a soil profile.

Overview

Using dry, sieved soil from horizon, students mix the soil with water and the dispersing solution to completely separate the particles from each other. Students shake the mixture to fully suspend the soil in the water. The soil particles are then allowed to settle out of suspension, and the specific gravity and temperature of the suspension are measured using a hydrometer and thermometer. These measurements are taken after 2 minutes and 24 hours.

Frequency

Three times for each horizon in a soil profile.

How to measure Particle Size Distribution?

1. Prepare the dispersing solution by mixing 50 g of Sodium Hexametaphosphate in 1 litre of distilled water. Stir or shake until the dispersing agent has completely dissolved.
2. Weigh 25 grams of dried, sieved soil and pour it into a 250 ml beaker or larger beaker.
3. Add 100 ml of the dispersing solution and about 50 ml of distilled water into the beaker. Stir vigorously with a spoon or stirring rod for at least one minute. Be sure the soil is thoroughly mixed and does not stick to the bottom of the beaker. Do not let any of the soil suspension spill out the top.
4. While the soil suspension is stirring, measure the distance between the base and the 500 mL mark of the cylinder. Place the meter stick inside the cylinder to get this measurement.

Read the temperature at which your hydrometer has been calibrated (such as 15.6^{0}C [600 F] or 20^0 C). This value is found on the body of the hydrometer.

5. Complete the top section of the Particle Size Distribution Data Sheet.
6. After at least 24 hours, stir the suspension in the container and pour it into a 500 mL graduated cylinder. Use a squirt bottle to rinse all soil out of the container and into the cylinder.
7. Add enough distilled water to fill the cylinder to the 500 mL mark.
8. Securely cover the top of the cylinder using plastic wrap or other cover. Place your hand over the mouth of the cylinder and mix the soil suspension vigorously by rotating the covered cylinder hand overhand at least 10 times.
9. Gently set the cylinder down in a safe place and immediately begin timing with a stopwatch or clock that has a second hand.
10. Record the time that the cylinder was set down to the second.
11. After one minute and 30 seconds has passed, carefully lower (do not drop) the hydrometer into the cylinder and leave it float in the soil suspension. Carefully steady the hydrometer to stop its bobbing motion.
12. At exactly 2 minutes after the cylinder was set down, read the line on the hydrometer that is closest to the surface of the soil suspension and record that number on the Particle Size Distribution Data Sheet.
13. Remove the hydrometer, rinse it away from the cylinder, dry it, and gently put down in a safe place.
14. Suspend the thermometer in the soil suspension in the cylinder for about 1 minute.
15. At the end of one minute, lift the thermometer from the suspension, read the temperature, and record the result on the Particle Size Distribution Data Sheet.
16. Rinse the thermometer off and dry it.
17. Leave the cylinder undisturbed for 24 hours. After 24 hours, take another hydrometer and temperature reading. Record the results on the Particle Size Distribution Data Sheet. (The 24 hrs hydrometer reading should be 24 hours from the initial timing start).
18. Discard the soil suspension by pouring it into a special pail and spill the contents outside in a special place for discarding soil materials.

Soil Moisture and Temperature Protocol: Field Measurements

Purpose

To measure near-surface temperatures.

Overview

Students measure soil temperatures at 5 cm and 10 cm depths using a soil thermometer.

Frequency

Soil temperature measurements can be taken daily or weekly. Seasonal measurements are taken every three months at 2 – 3 hour intervals for two consecutive days.

Calibrating the Soil Thermometer

1. Pour about 250 mL of water at room temperature into a beaker.
2. Place both the calibration thermometer and the soil thermometer into the water.
3. Check that water covers at least 4 cm of both thermometers. Add more water if needed.
4. Wait 2 minutes.
5. Read the temperatures from both thermometers.
6. If the temperature difference between the thermometers is less than 2^0 C, stop; your soil thermometer is calibrated.
7. If the temperature difference is greater than 2^0 C, wait two more minutes.
8. If the temperature difference is still greater than 2^0 C, adjust the soil thermometer by turning the calibration nut at the base of the dial with the wrench until the soil thermometer reading matches the calibration thermometer.

How to observe Soil Temperature?

1. Fill in the top portion of the Soil Temperature Data Sheet.
2. Locate your sampling point.
3. Use the nail to make a 5 cm deep pilot hole for the thermometer. If the soil is extra firm and you have to use a hammer, make a hole 7 cm deep. Pull the nail out carefully, disturbing the soil as little as possible. Twisting as

you pull may help. If the soil cracks or bulges out, move 25 cm and try again.

4. Insert the thermometer through a longer spacer so that 7 cm of the probe extends below. The dial should be against the top of the spacer.
5. Gently push the thermometer into the soil.
6. Wait 2 minutes. Record the temperature and time in your Science Log.
7. Wait one minute. Record the temperature and time in your science log.
8. If the two readings are within 1.0^0 C of each other, record this value and the time on the Soil Temperature Data Sheet as Sample 1, 5 cm reading. If the two temperatures are not within 1.0^0 C, continue taking temperature readings at one-minute intervals until 2 consecutive readings are within 1.0^0 C.
9. Remove the thermometer from the hole. (if the soil is soft, skip step 10).
10. Use the nail to deepen the hole to 10 cm. If you have a hammer, deepen the hole to 12 cm.
11. Replace the long spacer with the shorter one so that 12 cm of the thermometer extends below the bottom of the spacer. Insert the thermometer in the same hole. Gentle push down until the thermometer tip 12 cm below the surface.
12. Wait two minutes. Record the temperature and time in your Science log.
13. Wait one minute. Record the temperature and time in your Science Log.
14. If the 2 readings are within 1.0^0 C of each other, record this value and time on the Soil Temperature Data Sheet as Sample 1, 10 cm reading. If the 2 temperatures are not within1.0^0 C, continue taking temperature readings at 1-minute intervals until 2 consecutive readings are within 1.0^0 C.
15. Repeat steps 2 – 14 for 2 other holes 25 cm away from the first hole. Record these data on the Soil Temperature Data Sheet as Sample 2, 5 and 10 cm and sample 3, 5, and 10 cm.

Note: These three sets of measurements must all be made within 20 minutes.

16. Wipe clean all the equipment.
17. Read and record the current air temperature from the thermometer in the instrument shelter or following the Current Temperature Protocol in the Atmosphere Chapter.

Gravimetric Soil Moisture Protocol Field Measurements

Purpose

To measure soil water content by mass.

Overview

Students collect soil samples with a trowel or auger and weigh them, dry them, and then again weigh them. The soil water content is determined by calculating the difference between the wet sample mass and the dry sample mass.

Frequency

Soil moisture measurements should be done twelve times per year at the regular interval.

Measurement Procedure

The Soil Moisture Protocol offers three choices for sampling:

1. The Star Pattern

The Star Pattern involves collecting soil samples from 12 different locations at twelve different time periods in a 2 m X 2 m star-shaped area. For each of the 12 locations, three spots are chosen within 25 cm of each other. Samples from the top 5 cm and from 10 cm deep are collected at each of the three spots, for a total of 6 samples at each location on the star.

2. The Transect Pattern

The transect Pattern requires an open space of at least 50 m length. Thirteen samples are collected from the top 5 cm of soil.

3. The Depth Profile

The Depth Profile involves taking a sample of the top 5 cm and use of an auger to take soil samples at depths of 10 cm, 30 cm, 60 cm, and 90 cm.

How to measure Soil Moisture Protocol?

Star Pattern Soil Moisture Protocol

In the field

1. Complete the top portion of the Star Pattern Soil Moisture Data Sheet.
2. Locate your sampling point on the star and cut or pull away any grass or groundcover.
3. Dig a hole 10 – 15 cm in diameter down to 5 cm. Leave the soil loose in the hole.

4. Remove from the loose soil any rocks larger than a pea (about 5 mm), large roots, worms, grubs, and other animals.
5. Use your trowel to fill a soil container with at least 100 g of the loose soil.
6. Immediately seal the container to hold in the moisture.
7. Record the container mass and number on the Data Sheet next to Sample 1, 0-5 cm.
8. Remove all of the soil from the hole down to a depth of 8 cm.
9. In a clean container, collect a soil sample that contains the soil between 8 to 12 cm. Remember to remove rocks, large roots, and animals. Seal the container.
10. Record the container mass and number on the data sheet to sample 1, 10 cm.
11. Return remaining soil to the hole.
12. Repeat steps 3 – 11 twice in new holes within 25 cm of the original sample point filling the other four cans and recording the container number and masses for samples 2 and 3 at both depths. You should have six containers of soil taken from three holes.

Transect Soil Moisture Protocol

In the field

1. Complete the top portion of the Transect Pattern Soil Moisture Data Sheet.
2. Stretch out your rope or measuring tape along the transect you will measure.
3. Locate your sampling point along the transect. Sample points should be every 5 meters along the transect, plus 2 extra samples taken at one end of the transect within 25 cm of the end point. Sample points should be numbered starting with sample one at the beginning of the transect.
4. Cut or pull away any grass or ground cover above your sample point.
5. Dig a hole 10-15 cm in diameter down to 5 cm. Leave the soil loose in the hole.
6. Remove from the loose soil any rocks larger than a pea (About 5 mm), Large roots, worms, grubs, and other animals.
7. Use your trowel to fill your soil container with atleast 100 gms of the loose soil.
8. Immediately seal the container to hold in the moisture.
9. Record the container number, mass, and distance to the start point of the transect on the data sheet next to the appropriate sample number.

10. Continue to collect the sample at each sampling point along the transect. Remember to remove rocks, large roots and animals. Seal each container and record the sample number and distance from the start point of the transect on the datasheet.

Depth Profile Soil Moisture Protocol.

In the Field

1. Complete the top portion of Depth Profile Soil Moisture Data Sheet.
2. Locate your sampling point on the star and cut and pull away any grass or ground cover.
3. With the trowel, dig a hole 10-15 cm in diameter down to 5 cm. Leave this soil loose in the hole.
4. Remove from the loose soil any rocks larger than a pea (About 5 mm), Large roots, worms, grubs, and other animals.
5. Use your trowel to fill your soil container with at least 100 gms of the loose soil.
6. Immediately seal the container to hold in the moisture.
7. Record the container number and mass on the Data Sheet next to Sample Depth 0-5 cm.
8. Use the auger or trowel to remove all of the soil from the hole down to a depth of 8 cm.
9. In a clean container, collect the soil sample that contains the soil between 8 and 12 cm deep. Remove rocks, large roots and animals. Seal the container.
10. Record the Container number and mass on the data sheet next to sample depth 10 cm.
11. Continue to auger down to obtain samples centered at 30, 60, 90 cm. Record the container numbers and mass values on the data sheet.
12. You should have 5 containers of soil taken from one hole. Return the remaining soil to the hole- last soil out, first soil in.

In the Lab

1. Remove the lids from each soil samples.
2. Weigh the soil sample without the lid. Record the mass to the nearest 0.1 gm. As the wet weight next to the appropriate sample container number on the Soil Moisture Data Sheet.
3. Repeat step 2 for the remaining soil samples.
4. Dry your samples in your soil-drying oven.

5. When the samples are dry, fill in drying time and drying method on the data sheet.
6. Carefully remove the samples from the oven.
7. Weigh one of the dry soil samples. Record the dry weight to the appropriate container number on the Soil Moisture Data Sheet.
8. Repeat step 7 for each soil sample.
9. Empty the soil from the containers. Clean and dry each container. (You may save the soil samples in other sealed bags or containers for further tests or return the soil to your site.)

Note: Dried soil should be returned to the site to fill in holes so site may be used in future years.

$$\text{Soil Water Content} = \frac{(\text{Wet Mass} - \text{Dry Mass})}{(\text{Dry Mass} - \text{Container Mass})}$$

◆

Chapter V

HYDROLOGY INVESTIGATION

GLOBE Measurements

What measurements (basic) are taken?

- Transparency
- Water Temperature
- Electrical Conductivity
- Salinity
- pH
- Alkalinity

Where are measurements taken?

All Hydrology measurements are taken at the Hydrology Study Site. This may be any surface water site that can be safely visited and monitored regularly from school, although natural waters are preferred.

Ideally, the Hydrology Study Site will be within a watershed that is a prominent feature in the 15km X 15 KM GLOBE Study Site.

Site may be include (in order of preference)

1. Stream or river
2. Lake reservoir, bay or ocean
3. Pond

4. An irrigation ditch or other water body if one of the above is not accessible or available within your GLOBE Study Site.

You should collect all water samples from the same place at the hydrology site each time. This is called the sampling site.

Determine location

Once you have selected your hydrology site, be sure to identify the coordinates (latitude, longitude and elevation) of this site with the GPS receiver. Enter the location along with other site description information requested on the Hydrology Investigation Site Selection Data Entry Sheet.

When are measurements taken?

Collect all water measurements at roughly the same time each day, on a weekly basis. If your sampling site freezes over in winter or runs dry, be sure to enter this information on the data sheet each week until you again have free-flowing surface. Be observant of seasonal water to measure the monthly change.

Sampling Procedures

Quality Assurance and Quality Control

A quality assurance and quality control (QA / QC) plan is necessary to ensure that results obtained are as accurate and precise as possible. Reliability in both accuracy and precision is achieved by: -

- Practicing the measurement techniques of the protocol;
- Collecting the water sample as directed;
- Performing tests immediately after collecting the water sample;
- Carefully calibrating, using, and maintaining testing equipment;
- Following the directions of a protocol exactly as described;
- Repeating measurements to check their accuracy and to determine any sources of error;
- Minimizing contamination of stock chemicals and testing equipment;

- Checking to be sure the numbers submitted to the GLOBE Student Data Server are the same as recorded on the Hydrology Data Sheets; and
- Examining your data for reasonableness and anomalies.

Promptness and Sequences when Making Measurements

Tests for transparency, temperature and dissolved oxygen should be done on site immediately after obtaining the water sample. Do not let the bucket of water sit for more than a half hour before taking measurements. Dissolved Oxygen test should be done within 30 minutes of collection.

Sequences in which the measurements are performed are important. Transparency measurements should be taken first, followed immediately by the water temperature measurements and the dissolved oxygen test, then pH, electrical conductivity or salinity, and alkalinity.

Measure dissolved oxygen only if you measures water temperature.

For Repeated Measurements: Divide your class into at least two groups for each measurement. Both groups use the same bucket of water for the measurement.

If the values found by the 2 groups differ significantly, the measurement should be repeated.

The following are the maximum acceptable differences between the measured values.

Measurement	**Maximum Difference**
Transparency	1.0 cm
Water temperature	$0.5^{0}C$
Dissolved Oxygen	0.4mg/l (La Motte Kit) 1.0 mg / L (Hach Kit)
pH (using paper)	1.0 pH unit
pH (using pen or meter)	0.2 pH unit
Conductivity	2% of full scale (40ms/cm)
Salinity (hydrometer)	0.4 parts per thousand
Salinity (titration kit)	0.4 parts per thousand
Alkalinity	4 mg / L as $CaCo_3$ (La Motte Kit) 1 drop (Hach Kit) 17 mg / L as $CaCo_3$ (high range) 6.8 mg / L as $CaCo_3$ (low range)

Each group should use its own Hydrology Investigation Data Work Sheet. The value submitted to the GLOBE Student Data Server should be an average of all values obtained that meet the above criteria. Discard values that fall far outside the maximum differences.

How long does it take to do the measurements?

The amount of time for doing the measurements will depend upon the distance to your water site, the skill level of the students, and how your group is organized.

Hydrology Protocol

Water Transparency Protocol

Purpose

To determine water transparency using a Secchi disk (still, deep waters) or turbidity tube (flowing or shallow waters)

Overview

In still, deep water, students will lower the Secchi disk until it cannot be seen and then pull up the disk until it just reappears. In flowing or shallow water, students will collect a sample of water in a bucket and then pour water into the transparency tube just until the bottom of the tube cannot be seen. Students will record the depth of water in the tube. The depth of water for both the secchi disk and transparency tube depends on the amounts of suspended and colored material in the water.

Measurement Procedures

The transparency protocol asks for cloud cover measurements. Transparency measurements are made in shade.

Frequency

Weekly

Time

10 minutes

Materials and Tools

Secchi Disk Measurements

- Protocol Field Guide
- Secchi Disk (with rope)
- Meter Stick
- Clothespin

Turbidity tube Measurement

- Protocol Field Guide
- Bucket for collecting a water sample
- Transparency tube

GLOBE offers two techniques to measure the water transparency: -

SECCHI DISK: If the hydrology site is at water body that is deep and still (not flowing as a stream), use the Secchi Disk.

TRANSPARENCY TUBE: If the hydrology site is at water body that is shallow or flowing, the transparency of turbidity tube is used.

Secchi Disk Protocol

The Secchi Disk Transparency Protocol asks for three measurements:

1. The distance between the water surface and where the water disappears,
2. The distance between the water surface and where the water reappears,
3. The distance between the observer and the water surface.

If you are taking measurements at the water surface, then record “0” for the last measurement.

If the secchi disk reaches the bottom of the water body before it disappears, record the depth of the water with a “greater than” sign (e.g. > 30m)

Instrument Maintenance

1. Rinse the transparency tube or secchi disk with clean water after use, then let it drain and dry completely.
2. Store the tube with an extra PVC cap cover the open end to protect it from damage.
3. Do not store meter sticks inside the tube – dampness may wrap the stick or cause the varnish to peel off.

How to Make a Secchi disk:

- Divide top of wooden disk (20 cm diameter) into four quadrants.
- Paint two opposite quadrants in black and the other two in white.
- Screw a hook, screw into the top and bottom centre of the disk. Tie the 5 m (or longer) rope through the screw in the top of the disk.
- Tie a short piece of rope through the screw on the bottom of the disk and string it through the pipe. Tie a large knot at the bottom of the pipe so that it does not fall off when hanging vertically underneath the disk.
- Measure and mark the rope above the top part of the disk with the black marker every 10 cm.
- Measure and mark every 50cm from the disk with a blue marker and every meter with a red marker. Now you are ready to make a measurement.

How to make a Turbidity tube:

- On the bottom of the inside of the PVC cap, draw a disk pattern (alternating black and white quadrants) with the black marker.
- Put PVC cap over one end of clear tube. Cap should fit tightly so water cannot leak out.
- Use a marker and meter stick to make a scale on the side of the tube, beginning at the top of the disk with 0 cm.

How to Measure Transparency

Make sure that Secchi disk and turbidity/transparency tube measurements are made in the shade with the sun to your back to make an accurate and reproducible reading.

Whenever possible the transparency observation should be made by three different students and each of their observations submitted to the GLOBE Student Data Server.

Secchi Disk

1. Lower the disk slowly into the water until it just disappears. If possible, grab the rope at the surface of the water and mark this point on the rope. If it is not possible to mark the rope at the water surface mark the rope a known distance above the water.

2. Lower the disk another 10 cm into the water. Then raise the Secchi disk until it just reappears into view. Grab the line at the surface of water when the Secchi disk reappears and mark this point. The rope should now be marked at two points. There should only be a few centimetres difference between these two points.
3. Record both depths on your Hydrology Investigation Data Work Sheet to the nearest 1cm.
4. If the two depths differ by more than 10 cm, repeat the measurement.
5. Using the Cloud Cover Protocol, determine the cloud cover.
6. Determine the distances between where each observer marked the rope and the water surface. Record both on your Hydrology Investigation Data Worksheet. If the rope was marked at the water surface, enter "0".
7. Submit your depths along with the cloud cover and distance from the mark to the water surface to the GLOBE Student Data Server.

Note: -

If the Secchi Disk reaches the bottom of your study site and you can still see it, simply record the depth to the bottom by referring to the point where the rope is at the water surface and put a "greater then" (>) symbol in front of the measurement both on your data work sheet and when you submit the value to the GLOBE Student Data Server.

Turbidity Tube

1. Pour sample water slowly into the tube until the image at the bottom of the tube is no longer visible when looking directly through the water column at the image. Stop adding water when you cannot see the pattern at the bottom of the tube.
2. Rotate the tube slowly as you look to make sure you cannot see any of the pattern.
3. Record the depth of water on your Hydrology Investigation Data Work Sheet to the nearest 1cm.

Note: If you can still see the disk on the bottom of the tube after the tube is filled, record the depth as > 120 cm.

4. Pour the water from the tube back into the sample bucket or mix up the remaining sample.

5. Repeat the measurement two more time with different observers using the same sample.
6. Submit your depth to the GLOBE Student Data Server. Enter data for each observer, **not the average of the different observations**.

Water Temperature Protocol

Purpose

To measure the temperature of the water sample.

Overview

Students use an alcohol-filled thermometer to measure the temperature of water.

Time

10 minutes; Calibration: 5 Minutes

Frequency

Weekly, Calibration every three months

Materials and Tools

Alcohol filled thermometer, a clock, String to lower the thermometer into the water, Rubber band.

Calibration and Quality Control

This measurement takes only a few minutes to complete; the main concern is to allow sufficient time for the thermometer to equilibrate to the temperature of the water perhaps three to five minutes.

Your organic liquid filled thermometer should be calibrated at least every three months as well as before its first use. Calibrate it following the instructions in the Atmosphere Investigation Maximum, Minimum and Current Temperature protocol.

Measurement Procedures

Except for transparency, water temperature is taken before the other water measurements. Take the water temperature measurements as soon as possible after the water sample is taken because temperature tends to change very rapidly after the sample is collected.

Read the temperature value on the thermometer while the bulb of the thermometer is in the water. The temperature reading can change quickly once the thermometer is out of the water, especially when the air temperature is very different from the water temperature or windy.

Instrument Maintenance

1. Make sure that the string and the rubber band attached to the thermometer are not frayed before each other.
2. Store the thermometer upright in the beaker or other holder. Storing the thermometer on its end prevents the alcohol column from separating.
3. Make sure that the alcohol column is continuous and has not become separated.

How to Measure Water Temperature

1. Tie one end of a piece of string securely to the end of the thermometer and the other end to a rubber band. Slip the rubber band around the wrist so that the thermometer is not lost if it is accidentally dropped in the water.
2. Hold the end of the thermometer (opposite the bulb) and shake it several times to remove any air in the enclosed liquid. Note the temperature reading.
3. Immerse the thermometer to a depth of 10cm in the sample water for three to five minutes.
4. Raise the thermometer only as much as is necessary to read the temperature. Quickly note the temperature reading. If the air temperature is significantly different from the water temperature try to take the reading while the bulb of the thermometer is still in the water. Lower the thermometer for another minute or until it stabilizes. Read it again. If the temperature is unchanged, proceed further.
5. Record this temperature along with the date and time.
6. Take the average of the temperatures measured by the student's groups. If all the measured values are within 1.0^0C of the average, submit the average value to the GLOBE Student Data Server. Otherwise, repeat the measurement.

Dissolved Oxygen Protocol

Purpose
To measure the amount of oxygen dissolved in the water sample.

Overview
Dissolve oxygen is closely related to survival of plants and animal life in all bodies of water. It is affected by natural processes and by human activities.

Frequency
Weekly, calibration every six months.

Materials and Tools
Dissolved Oxygen kit, Distilled water, 250ml polyethylene bottle with top thermometer.

Calibration and Quality control
Calibration should be performed every six months to verify your technique and the integrity of your chemicals.

1. Rinse a 250ml bottle twice with distilled water. Measure 100ml of distilled water with a graduated cylinder.
2. Pour this water into the 250ml of bottle. Put the lid on tightly and shake it vigorously for 5 minutes.
3. Uncap the bottle and take the temperature of the water be sure the tip of the thermometer does not touch the bottom or sides of the bottle. Wait 1 minute before reading the temperature.
4. Record the temperature.
5. Follow directions to measure dissolved oxygen.
6. On the data sheet, record the value as mg/L DO (dissolved oxygen) for the distilled water standard. The mg/L DO found using the shaken standard must be within .04 mg/L of the expected value for a shaken (thus saturated with oxygen) distilled water sample. To find the expected value for a saturated do distilled water sample.
7. Look up the temperature of your standard Table HYD – 1
8. Look at the corresponding solubility of oxygen (mg/L) and record it on the sheet.

9. Look at the calibration value in Table HYP p/n Z corresponding to your elevation in meters and record it.
10. Multiply the solubility of oxygen by the calibration value. The value that comes is your expected value for a taken distilled water standard.
11. Compare this value to the value for DO that you found when you tested your shaken, distilled water standard. If the value is not within 0.4mg/l (La Motte Kit) or mg/L (Hach Kit) try the measurement again on the distilled water.

How to Measure Dissolved Oxygen

Sampling Procedure

1. Rinse the sampling bottle and rinse with sample water three times, Rinse vial three times in distilled water.
2. Replace the cap on the bottle.
3. Submerge the bottle in sample water and remove the cap allow the container to fill.
4. Tap the bottle to release air bubbles.
5. While the bottle is submerged, replace the cap. Remove the capped bottle from the water.
6. Check to ensure that no bubbles are present in the bottle. If bubbles are found, repeat the sampling procedure.

Sample Preservation and Testing Procedure

1. Use a dissolved oxygen test kit that meets the specifications in the tool kit. Follow the instructions carefully. If a scoop is used to measure powdered chemicals, do not allow the scoop to come in contact with the liquid.
2. Record the values from the student groups.
3. Take the average of the DO values measured by the student groups. If the values are all within mg/l of the average, submit the average DO value to the GLOBE Student Data Server.

DO tests kits involve two overall parts sample preservation and sample testing. The preservation part involves the addition to the sample of the chemical that precipitates in the presence of dissolved oxygen, followed by addition of a chemical that produces a coloured solution. The testing part involves drop wise addition of a titrant solution until the colour disappears. The DO value is calculated from the volume of titrant added.

pH Protocol

Purpose

To measure the pH of the water at the hydrology site.

Overview

The pH of the water sample is a key factor in determining what can live in water.

Frequency

Weekly including calibration

Materials and Tools

For Method 1

pH indicator paper (beginning)
50 or 100ml beakers

For Method 2

pH pen (Intermediate / Advanced)
One jewellery screwdriver (for calibration)
Three 50 or 100ml beaker
pH buffer solution for pH 7
pH meter (Intermediate / Advanced)
Five 50 or 100ml beakers
Three pH buffer solutions for pH 4, 7, and 10
100ml-graduated cylinder
Soft tissues, Distilled water

Background

This Protocol involves determining the pH of the water sample from your Hydrology Study Site. We suggest that beginning level students use pH indicator paper, intermediate level student use a pH pen and advanced level students use a pH meter.

How to Measure pH

Method 1: pH indicator paper

Beginning level

Same as given in the Atmosphere Study Section

Method 2: pH pen or pH meter

Same as given in the Atmosphere Study Section

Note: - pH pen or meter readings may not be accurate if your water sample has a conductivity below 100 Micro Siemens / cm (pH pens and meters do not function properly below this level).

Electrical Conductivity Protocol

Purpose

To measure the conductivity of the water at the Hydrology Study Site.

Overview

Conductivity is a measure of the amount of total dissolved solids in the water.

Frequency

Weekly including calibration

Materials and Tools

Total dissolved solid tester (or conductivity tester),

Standard solution,

Distilled water,

Squeeze bottle.

Three 50ml or 100ml beakers,

Screwdriver (for calibration).

Background

Conductivity is measured in Micro Siemens / Centimeter (ms/cm). A micro Siemen is the same as a micromho. Conductivity of a water sample is a measure of its ability to carry an electric current. The more impurities (total dissolved solids) in water, the greater its electrical conductivity. By measuring the conductivity of water sample the amount of total dissolved solids in the sample can be determined. To convert the electrical conductivity (Micro Siemens/cm) of a water sample to the concentration of total dissolved solids (PPM) in the sample the conductivity must be multiplied by a factor of between 0.54 - .096 for natural waters. The value of this factor depends upon the type of dissolved solids. A widely accepted value to use when you are not determining the type of dissolved solids in 0.67.

TDS (ppm) = conductivity (micro siemens/cm) × 0.67

Calibration

The conductivity meter should be calibrated before each set of measurements. Before use and every six months the temperature compensation should be checked.

1. Bring the standard solution to room temperature (about 25^0 C)
2. Pour standard solution into each of the two clean 100 mL beakers or cups to a depth of about 2 cm.
3. Remove the cap from the electrical conductivity tester and press the On/Off button to turn the tester on.
4. Rinse the electrode at the bottom of the tester with distilled water in the wash bottle.
5. Gently blot it dry with a soft tissue.

   Note: Do not rub or stroke the electrode while drying.
6. Put the electrode of the meter into the first beaker of standard solution. Stir gently for 2 second to rinse off any distilled water.
7. Take the meter out of the first beaker. Do NOT rinse with distilled water.
8. Dip it into the second standard solution beaker.
9. Stir gently, and then wait for the numbers to stop changing.
10. If the display does not read the value of your standard solution, you must adjust the instrument to read this number. (for most meters you can use a small screwdriver to adjust the calibration screw on the meter until the display reads the standard value).
11. Rinse the electrode with distilled water and blot it dry. Turn off the meter and put the cap on to protect the electrode.
12. Pour the standard from the beaker into a waste container. Rinse and dry the beaker.

Temperature Compensation Check

Conductivity measurements are affected by the water sample temperature. Your meter should be temperature compensated to give a conductivity reading equivalent to a temperature of 25^0C measure the conductivity of your standard at 5,15,25 and 35^0C. If the conductivity reading is outside the specified range (+ / - 40ms/cm) for your standard at 25^0C then contact the manufacturer.

Quality Control in the Field

Whether the tester is calibrated in the classroom or in the field, the standard solution must be tested with the following protocol as if it were a water sample. When tested the standard should read its true value. If it does not, the instrúment must be recalibrated and the conductivity measurement made again.

How to Measure Conductivity

1. Fill out the top portion of the Hydrology Investigation Data Sheet.
2. Put on latex gloves.
3. Record the temperature of the water to be tested. If the water is between $20^0 - 30^0$ C, go to step 5.
4. If your water is below 20^0 C or above 30^0 C, fill a clean sample bottle (600-700 mL) with the water to be tested. Cap and bring back to the classroom. Allow the water to reach 20^0-30^0 C, record the temperature, and proceed to step 5.
5. Rinse two 100 mL beakers two times with sample water.
6. Pour about 50 mL of water to be tested into two 100 mL beakers.
7. Remove cap from the meter and press the ON/OFF button to turn the tester on.
8. Rinse the electrode with distilled water and blot it dry. Do NOT rub or stroke the electrode while drying.
9. Immerse the electrode in the water sample in the first beaker, gently stir the sample for a few seconds. Do not let the meter rest on the bottom of the beaker or touch the sides.
10. Take the meter out of the first beaker. Shake gently to remove excess water, then put it into the second beaker without rinsing with distilled water.
11. Leave the electrodes submerged for at least one minute. When the numbers stop changing, record the value on the *Hydrology Investigation Data Sheet by Observer 1.*
12. Have two other students repeat the measurement using fresh beakers of water each time. The meter does not need to be calibrated for each student. Record these measurements as *Observers 2 and 3.*
13. Calculate the average of the three Observations.

14. Each of the Observations should be with in 40 ∝S/cm of the average. If the recorded values are all within 40 micro Siemens/cm of the average, report the average value to the GLOBE Student Data Server.
15. If one or more of the values is not with in 40 ∝S/cm, pour a fresh sample, repeat the measurements, and calculate a new average. If all observations still are not within 40.0 of the average, discuss possible problems with your teacher.
16. Rinse the electrode with distilled water, blot dry, and put the cap on the meter. Rinse and dry the beakers and sample bottle.

Salinity Protocol

Purpose

To measure the salinity of the water at your Hydrology Study Site.

Overview

Students will use a hydrometer to measure the specific gravity of the water sample, and use a thermometer to measure temperature. With these two values, students will use tables to determine the salinity.

The salt content (salinity) of a water body is one of the main factors determining what organisms will be found in the water body. The density of water is related to the amount of salt dissolved in it.

Frequency

Weekly

Quality control check every six months

Materials and Tools

Hydrology Investigation Data Sheet, Hydrometer, Conversion Table, 500 ml Clear Plastic Graduated Cylinder, Alcohol filled thermometer, Table Salt (NaCl), Distilled water, Balance, Two 1-liter Plastic Bottles with caps, masking tape.

Quality Control Procedure for Salinity Protocol

Make the 35 ppt Standard

1. Measure 17.5 g of the table salt (NaCl) with the balance.
2. Pour the salt into the 500-mL cylinder.

3. Fill the cylinder to the 500 mL line with distilled water.
4. Gently mix the salt and water until all of the salt is dissolved This is your 35-ppt standard.

Check your Hydrometer Using Distilled Water

1. Pour 500 mL of distilled water into the 500-mL cylinder
2. Put the thermometer in the distilled water. Use the Water Temperature Field Guide to measure the water temperature record on the Hydrology Investigation Quality control Procedure Data Sheet.
3. Place the hydrometer gently into the water. After it stops bobbing, read the specific gravity at the bottom of the meniscus. It should not touch the sides of the cylinder. Read to three places and record on the Hydrology Investigation Quality Control Procedure Data Sheet.
4. Look up the specific gravity and temperature on the conversion table. The salinity should be between 0.0 and I .0 ppt.
5. If the salinity is not between 0.0 and 1.0 ppt, recheck your measurements. If the salinity is still not between 0.0 and 1.0 ppt, your hydrometer is not reading correctly.

Check your Hydrometer Using the Standard

1. Put the standard in a 500-mL cylinder.
2. Put the thermometer in the distilled water. Use the Water Temperature Field Guide to measure the water temperature. Record on the Hydrology Investigation Quality Control Procedure Data Sheet.
3. Gently place the hydrometer into the cylinder. When it stops bobbing, read the specific gravity at the bottom of the meniscus. It should not touch the sides of the cylinder. Read to three places and record on the Hydrology Investigation Quality Control Procedure Data Sheet.
4. Look up the specific gravity and water temperature on the conversion table to find the salinity of the water. Record the salinity on the Hydrology Investigation Quality Control Procedure Data Sheet.
5. If the salinity standard is off by more than I ppt mix a new standard and repeat the procedure. If it is still off by more than I ppt talk to your teacher about possible problems.

6. Discard the 35-ppt standard or pour it into a clean and dry 1-L bottle, cap, and label. Rinse equipment with distilled water, dry and store.

Times of High and Low Tide

Obtain the times of high and low tide for the location nearest your site for which these are available. The times reported should be for the high or low tide immediately preceding and following the time you take your measurements.

How to Measure Salinity

1. Fill out the top portion of your hydrology investigation Data Sheet.
2. In the Salinity section of the Hydrology Investigation Data Sheet, record the times of the high tide and low tide that occur before and after your salinity measurement is taken. Also record the place where the times from your Tide table Occur.
3. Put on Gloves.
4. Rinse the 500-mL cylinder with sample water twice.
5. Fill the cylinder with sample water to within 2 or 3 cm of the top.
6. Measure and record the temperature of the water in the cylinder. (See Hydrology Investigation Temperature Protocol Field Guide)
7. Gently put the hydrometer into the cylinder.
8. Wait for the hydrometer to stop bobbing. It should not touch the sides of the cylinder.
9. Read the hydrometer at the bottom of the meniscus. Read the specific gravity to three decimal places. Record the specific gravity on the *Hydrology Investigation Data Sheet.*
10. Look up the specific gravity and water temperature on the Conversion Table to find the salinity of water. Record the salinity on the *Hydrology Investigation Data Sheet* as *Observer 1.*
11. Repeat Steps 3-9 using new samples of water. Record the salinity measurements as *Observers* 2 and 3.
12. Calculate the Average of the three measurements.

    Each of the three measurements should be within 2 ppt average. Submit the values of temperature, specific gravity, and salinity to the GLOBE Student Data Server.
13. If one or more of the observations is not within 2.0 ppt of the new average, talk to your teacher about possible problems.

Optional Salinity Titration Protocol

Purpose

To measure the salinity of the water sample using the more accurate salinity titration method.

Overview

The major dissolved constituents (salts) in seawater are found in relatively constant proportion. By measuring the concentration of any one of them in seawater samples, in this case chloride, the water sample's salinity can be inferred.

Frequency

Weekly, Calibration every six months

Materials and Tools

Salinity Titration Test kit, 1 litre plastic bottle, Table salt (NaCl), Distilled water, Graduated cylinder, Balance.

Calibration and Quality Control

Calibrations should be performed at least every six months to verify your technique and the integrity of your chemicals. Fresh standards should be prepared annually.

Salinity Standards

Salinity standards do not come with the Salinity Titration Kit, and one needs to prepare as follows.

- Add water to table salt to make a sea water titration standard of 38.6ppt salinity. Use this standard to test the accuracy of the Salinity Titration Test Kit.
  1. Measure out 17.5g NaCl (table salt) using an analytical balance. Pour this into a 500ml-graduated cylinder.
  2. Fill the cylinder to the line with distilled water.
  3. Carefully swirl the solution to mix the standard.
  4. Pour the solution into a 1 litre plastic bottle and label it (include the data)
- Follow directions in the Protocol section to measure the standards. Where it says "sample water" use the standard that you made.
- Record the value of the standards after testing.

- If salinity standards are off by more than 0.4ppt, prepare new standards and repeat the measurement.

Times of High and Low Tide

Obtain the times of high and low tied for the location nearest your site for which these are available. The times reported should be for the high or low tide immediately preceding and following the time you make your measurements.

How to Measure Salinity

1. Use a salinity titration test kit, which meets the GLOBE instruments specifications in the Toolkit. The kits are based on the techniques of adding a color indicator to the sample and then adding on acid titrant drop wise until a color change is observed.
2. Follow the manufacturer's instruction on the kit. To titrate more saline water than 20 parts per thousand (ppt) refill the titrator with acid, keeping a record of the total amount of acid used.
3. Record the salinity in ppt.
4. Take the average of the salinity values measured by the students groups. If the recorded values are all within 0.4 ppt of the average, submit the average off to the GLOBE Student Data Server. If they are not within 0.4ppt of the average have the students retitrate the sample, then record and average the new values.
5. Put all liquids in waste bottles.

Alkalinity Protocol

Purpose

To measure the alkalinity of the water sample.

Overview

Students will use an alkalinity kit to measure the alkalinity in the water at their hydrology site.

Alkalinity is closely related to the kinds of aquatic life that will survive in water.

Frequency

Weekly, Calibration every six months.

Quality Control Procedure: twice a year

Materials and Tools

Alkalinity Test Kit, Baking soda (sodium bicarbonate) Distilled water bottle, Distilled water, 500ml beaker, 100ml graduated cylinder, 500 ml graduated cylinder, sample bottle.

Making the Baking Soda Alkalinity Standard

In the lab

1. Using your balance, weigh out 1.9 g baking soda and add it to your 500ml-graduated cylinder.
2. Fill the 500ml-graduated cylinder to the 500ml mark with distilled water.
3. Pour this solution into the 500ml beaker, and stir it with a stirring rod to make sure all of the baking soda has dissolved.
4. Pour 15ml from the beaker into the 100ml-graduated cylinder.
5. Rinse the 500ml-graduated cylinder with distilled water first pour the 15ml of your baking soda solution into the 500ml-graduated cylinder.
6. Fill the 500ml-graduated cylinder to the 500ml mark with distilled water.
7. The solution in your 500ml-graduated cylinder is your standard and has an alkalinity of approximately 84 mg/L.

Note: The true alkalinity of this baking soda standard is 68mg/l as $CaCo_3$. The true value for distilled water is usually below 14mg/l.

Quality Control Procedure for Alkalinity

1. Put on the gloves and goggles.
2. Fill in the top portion of the Hydrology Quality Control Data Sheet. Make sure to note the type of alkalinity standard you are using, as well as your kit manufacturer and model number.
3. Measure the alkalinity of your standard solution following your kit's directions.

   Note: Use the alkalinity standard as your water sample.
4. Record the results on the Hydrology Quality Control Data Sheet.
5. Compare your results with the value of your alkalinity standard.

If you are using the baking soda standard, your results should be 84 mg/L plus or minus 10 mg/L.

- If you are using a ready-made standard, your results should be the actual alkalinity of your standard plus or minus the maximum acceptable difference for your test kit.

Maximum acceptable differences for common alkalinity test kits.

LaMotte	+ 8 mg/L
Hach	+ 6.8 mg/L (Low range, 0-10 mg/L)
	+ 17 mg/L (High Range 0-50 mg/L)

6. If your measured values are not within the expected range, try doing the procedure again using a fresh standard sample.
7. If your value is still not within range discuss possible problems with your teacher.

How to Measure Alkalinity

In the Field

If your alkalinity kit has both a low range protocol and a high range protocol, use the low range protocol unless your water sample has an alkalinity greater than about 125mg/l as $CaCo_3$. This will enable you to make more precise measurements.

1. Fill out the top portion of your Hydrology Investigation Data Sheet.
2. Put on the gloves and goggles.
3. Use an alkalinity test kit, which meets the GLOBE Instruments Specifications. Follow the manufacturer's instructions the kits are based on the technique of adding a color indicator to the sample and then adding an acid titrant drop wise until a color change is observed.
4. Record the total alkalinity in mg/l as $CaCo_3$.
5. Take the average of the alkalinity values measured by the student groups.
6. Each of your individual measurements should be within the acceptable range of the average.

Maximum acceptable differences for common alkalinity test kits.

LaMotte	+ 8 mg/L
Hach	+ 6.8 mg/L (Low range, 0-10 mg/L)
	+ 17 mg/L (High Range 0-50 mg/L)

7. If the measurement is outside this range, discard that measurement and find the average of the other two.
8. If they are still in range, report only the two measurements.
9. If more than two of your measurements are not in range, repeat step 3.
10. Submit the average value to the GLOBE Student Data Server.

Nitrate Protocol

Purpose

To measure nitrate-nitrogen ($NO_3 - N$) of water at the hydrology study site.

Overview

Student will use a nitrate kit to measure the nitrate-nitrogen in the water at their hydrology. Nitrogen exists in water in numerous forms, two of which are Nitrite (No_3) and Nitrate (No_2). Of these forms nitrate is usually the most important Nitrite can be found in sub toxic water. Nitrate is an essential nutrient for growth of algae and other aquatic plants, and can be present at high levels due to inputs from a variety of sources. Nitrate is very difficult to measure directly, so it is reduced to nitrite and the resulting nitrite concentration is measured the measurement gives the combined concentration of nitrite (if present) and nitrate concentration.

Materials and tools

50ml beaker Nitrate Test Kit, 100ml and 500ml graduated cylinder, three 500ml bottles, Distilled waters, standard nitrate solution (1000 mg/L nitrate-nitrogen).

Calibration and Quality Control

Standards should be run at least every 6 months to verify your technique and the integrity of your chemicals. Fresh standards should be prepared each time.

Nitrate Standards Prepared as follows:

Stock Nitrate Solution: - Dry KNO_3 (potassium nitrate) in an oven for 24 hours at 105^0C. Then dissolve 3.6g of KNO_3 in distilled water. Dilute to 500ml in your 500ml graduate cylinder using distilled water. Carefully swirl the solution to mix. Store in a 500ml bottle label it (include date). This makes a 7200mg/l KNO_3 (or a 1000mg/l nitrate nitrogen) solution.

Note: - To calculate nitrate nitrogen take into account the molecular composition of KNO_3 (the ratio of the molecular weight of N to KNO_3 is 0.138) 7200mg/l KNO_3 $\times 0.138 \cong 1000$mg/l nitrate nitrogen.

Standard Nitrate Solution

Measure 50 ml of the stock nitrate solution using the 100ml-graduated cylinder. Pour into the 500ml-graduated cylinder and dilute to 500ml with distilled water. Carefully swirl the solutions to mix. The result is 100mg/l nitrate nitrogen standard. Store in a 500ml bottle label the bottle (include date).

Make a new stock nitrate solution each time a calibration is conducted if the stock solution has not been preserved standard nitrate solutions should be made fresh each time regardless of whether the stock solution has been preserved or not.

Quality Control Procedure

1. Dilute the 100mg/l standard to make a 2 mg/l standard. Use this standard to test the accuracy of the nitrate kit. Measure out 10ml of the 100mg/l standard nitrate solution using the 100ml graduated cylinder. Pour this into the 500ml flask. Measure out 490ml of distilled water and add to 500ml bottle Label it (include date). Carefully swirl the solutions to mix the standard.
2. Follow the directions in the Protocol section to measure the standard.
3. Record the value of the standard after testing.
4. If the nitrate standards is off by more than 1mg/l prepare new dilutions and repeat the measurement.

How to Measure Nitrate Nitrogen

- Use a nitrate measurements kit, which meets the GLOBE Instrument specifications in the toolkit. Rinse the sample tubes in the kit at least 3 times with sample water before starting the measurements.
- Nitrate nitrogen plus nitrite nitrogen

Follow the manufacturer's nitrate instrument in the kit. The kits are based on the technique of adding a reagent that reacts with nitrate to form nitrite. The nitrite reacts with a second reagent to form a colour.

The intensity of the color is proportional to the amount of nitrate in the sample. The concentration is determined by comparing the sample color, after addition of reagents, to a color comparator included in the kit. If the kit calls for shaking the sample, be sure to shake for the specified period of time.

- Have at least 3 students in the group read the color comparator. Record the nitrate concentration for each student group.
- Take the average of three readings. If the recorded values are all within 1mg/l of the average record the average on sheet. If they are not within 1mg/l of the average have the students reread the colour comparator. Report a value to average Data Server.
- Nitrite Nitrogen: - Follow the manufacturer's instruction for nitrite. It is the same procedure except the reagent to reduce nitrate. nitrite is not used.

Tests result should be reported as mg/l nitrate nitrogen and not as mg/l nitrate (NO_3).

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Table HY-SA-1: Tide Table

Tide Predictions (High and Low Waters) August, 2002

Source: NOAA, National Ocean Service

Daylight Saving Time

Day	Time	Ht.	Time	Ht.	Time	Ht.	Time	Ht.
1 Th	131am L	0.6	730am H	2.0	106pm L	0.8	740pm H	2.6
2 F	233am L	0.5	841am H	1.9	206pm L	1.0	832pm H	2.7
3 Sa	335am L	0.3	956am H	1.9	313pm L	1.1	928pm H	2.7
4 Su	432am L	0.1	1105am H	2.0	417pm L	1.1	1024pm H	2.8
5 M	526am L	-0.2	1204pm H	2.2	516pm L	1.0	1118pm H	2.9
6 Tu	616am L	-0.4	1256pm H	2.3	611pm L	0.9		
7 W	1209am H	3.0	703am L	-0.6	143pm H	2.5	702pm L	0.8
8 Th	1258am H	3.2	747am L	-0.7	228pm H	2.6	751pm L	0.6
9 F	147am H	3.2	831am L	-0.8	309pm H	2.7	839pm L	0.5
10 Sa	237am H	3.2	913am L	-0.7	349pm H	2.8	927pm L	0.3
11 Su	327am H	3.2	955am L	-0.6	428pm H	2.9	1017pm L	0.2
12 M	419am H	3.0	1037am L	-0.4	508pm H	3.0	1109pm L	0.1
13 Tu	514am H	2.8	1121am L	-0.1	549pm H	3.0		
14 W	1206am L	0.1	614am H	2.5	1209pm L	0.2	634pm H	3.0
15 Th	108am L	0.1	721am H	2.3	104pm L	0.5	725pm H	3.0
16 F	215am L	0.0	837am H	2.1	206pm L	0.8	824pm H	2.9
17 Sa	323am L	0.0	956am H	2.1	313pm L	0.9	928pm H	2.9
18 Su	428am L	-0.1	1110am H	2.2	419pm L	1.0	1032pm H	2.9
19 M	527am L	-0.2	1211pm H	2.3	521pm L	0.9	1130pm H	2.9
20 Tu	618am L	-0.3	101pm H	2.5	616pm L	0.8		
21 W	1221am H	2.9	703am L	-0.3	142pm H	2.6	705pm L	0.7
22 Th	106am H	2.9	744am L	-0.3	220pm H	2.7	750pm L	0.6
23 F	148am H	2.9	821am L	-0.3	254pm H	2.7	831pm L	0.5
24 Sa	228am H	2.8	856am L	-0.2	326pm H	2.7	910pm L	0.5
25 Su	307am H	2.8	928am L	0.0	355pm H	2.7	949pm L	0.4
26 M	346am H	2.7	1000am L	0.2	423pm H	2.7	1027pm L	0.4
27 Tu	426am H	2.5	1029am L	0.3	450pm H	2.7	1107pm L	0.4
28 W	510am H	2.3	1058am L	0.5	519pm H	2.7	1152pm L	0.4
29 Th	600am H	2.2	1129am L	0.8	551pm H	2.7		
30 F	1244am L	0.4	659am H	2.0	1208pm L	1.0	633pm H	2.6
31 Sa	146am L	0.4	810am H	2.0	113pm L	1.2	730pm H	2.6

Note: Heights in this table are in meters. Many tide tables in the United States and in Canada are in feet. To convert feet to meters, divide the data by 3.28 ft/m.

All tide tables (including this one) are in local time. You will need to convert to UT.

Table HY-DO-1: Solubility of Oxygen in Fresh Water Exposed to Air at 760 mm Hg Pressure

Temp °C	Solubility mg/L	Temp °C	Solubility mg/L	Temp °C	Solubility mg/L
0	14.6	16	9.9	32	7.3
1	14.2	17	9.7	33	7.2
2	13.8	18	9.5	34	7.1
3	13.5	19	9.3	35	7.0
4	13.1	20	9.1	36	6.8
5	12.8	21	8.9	37	6.7
6	12.5	22	8.7	38	6.6
7	12.1	23	8.6	39	6.5
8	11.9	24	8.4	40	6.4
9	11.6	25	8.3	41	6.3
10	11.3	26	8.1	42	6.2
11	11.0	27	8.0	43	6.1
12	10.8	28	7.8	44	6.0
13	10.5	29	7.7	45	5.9
14	10.3	30	7.6	46	5.8
15	10.1	31	7.4	47	5.7

Table HY-DO-2: Correction Values For Various Atmospheric Pressures and Elevations

Pressure millibars	elev m	Correction value %	Pressure millibars	elev m	Correction value %
1023	-84	1.01	841	1544	0.83
1013	0	1.00	831	1643	0.82
1003	85	0.99	821	1743	0.81
993	170	0.98	811	1843	0.80
988	256	0.97	800	1945	0.79
973	343	0.96	790	2047	0.78
963	431	0.95	780	2151	0.77
952	519	0.94	770	2256	0.76
942	608	0.93	760	2362	0.75
932	698	0.92	750	2469	0.74
922	789	0.91	740	2577	0.73
912	880	0.90	730	2687	0.72
902	972	0.89	719	2797	0.71
892	1066	0.88	709	2909	0.70
882	1160	0.87	699	3203	0.69
871	1254	0.86	689	3137	0.68
861	1350	0.85	679	3253	0.67
851	1447	0.84	669	3371	0.66

Table HY-SA-2: Salinity (parts per thousand) as a function of specific gravity and temperature (as of 2/2002)

	Temperature of Water (°C)																
Observed Reading	**-2**	**-1**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
0.998																	
0.999																	
1																	
1.001	2	1.9	1.9	1.8	1.8	1.5	1.5	1.5	1.5	1.5	1.5	1.8	1.8	1.9	1.9	2	2.1
1.002	3.3	3.2	3.2	3.1	2.9	2.9	2.9	2.8	2.8	2.9	2.9	2.9	3.1	3.2	3.3	3.4	3.6
1.003	4.6	4.5	4.4	4.2	4.2	4.1	4.1	4.1	4.1	4.1	4.2	4.2	4.4	4.5	4.6	4.7	4.9
1.004	5.8	5.7	5.5	5.5	5.4	5.4	5.4	5.4	5.4	5.4	5.5	5.5	5.7	5.8	5.9	6.1	6.2
1.005	7.1	7	6.8	6.7	6.7	6.7	6.6	6.6	6.7	6.7	6.7	6.8	6.8	7	7.1	7.2	7.5
1.006	8.3	8.1	8.1	8	7.9	7.9	7.9	7.9	7.9	8	8	8.1	8.1	8.3	8.4	8.5	8.8
1.007	9.4	9.4	9.3	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.3	9.4	9.4	9.6	9.7	9.8	10.1
1.008	10.7	10.6	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.6	10.6	10.7	10.9	11	11.1	11.3
1.009	11.9	11.8	11.8	11.7	11.7	11.7	11.7	11.7	11.8	11.8	11.9	11.9	12	12.2	12.3	12.4	12.6
1.01	13.2	13.1	13	13	13	13	13	13	13	13.1	13.1	13.2	13.3	13.5	13.6	13.7	13.9
1.011	14.4	14.3	14.3	14.1	14.1	14.1	14.1	14.3	14.3	14.4	14.4	14.5	14.7	14.8	14.9	15	15.2
1.012	15.6	15.6	15.4	15.4	15.4	15.4	15.4	15.4	15.6	15.6	15.7	15.8	16	16.1	16.2	16.3	16.5
1.013	16.9	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.7	16.9	17	17.1	17.1	17.3	17.5	17.6	17.8
1.014	18	18	17.9	17.9	17.9	17.9	17.9	18	18	18.2	18.3	18.3	18.4	18.6	18.8	19	19.1
1.015	19.3	19.2	19.2	19.2	19.2	19.2	19.2	19.2	19.3	19.3	19.5	19.6	19.7	19.9	20.1	20.3	20.4
1.016	20.5	20.5	20.4	20.4	20.4	20.4	20.5	20.5	20.6	20.6	20.8	20.9	21	21.2	21.4	21.6	21.7
1.017	21.7	21.7	21.7	21.7	21.7	21.7	21.7	21.8	21.8	21.9	22.1	22.2	22.3	22.5	22.6	22.9	23
1.018	23	23	23	22.9	22.9	23	23	23	23.1	23.3	23.4	23.5	23.6	23.8	23.9	24.2	24.3
1.019	24.2	24.2	24.2	24.2	24.2	24.2	24.3	24.3	24.4	24.6	24.7	24.8	24.9	25.1	25.2	25.5	25.6
1.02	25.5	25.5	25.5	25.3	25.5	25.5	25.5	25.6	25.6	25.7	25.9	26	26.1	26.4	26.5	26.8	26.9
1.021	26.6	26.6	26.6	26.6	26.6	26.8	26.8	26.9	26.9	27	27.2	27.3	27.4	27.7	27.8	28.1	28.2
1.022	27.9	27.9	27.9	27.9	27.9	27.9	28.1	28.1	28.2	28.3	28.5	28.6	28.7	29	29.1	29.4	29.5
1.023	29.1	29.1	29.1	29.1	29.1	29.2	29.2	29.4	29.5	29.6	29.8	29.9	30	30.2	30.4	30.7	30.8
1.024	30.4	30.4	30.4	30.4	30.4	30.4	30.5	30.7	30.8	30.8	31.1	31.2	31.3	31.5	31.7	31.9	32.1
1.025	31.6	31.6	31.6	31.6	31.7	31.7	31.9	31.9	32	32.1	32.2	32.4	32.6	32.8	33	33.2	33.4
1.026	32.9	32.9	32.9	32.9	32.9	33	33	33.2	33.3	33.4	33.5	33.7	33.9	34.1	34.3	34.5	34.7
1.027	34.1	34.1	34.1	34.2	34.2	34.2	34.3	34.5	34.6	34.7	34.8	35	35.2	35.4	35.6	35.8	36
1.028	35.2	35.4	35.4	35.4	35.4	35.5	35.6	35.8	35.8	36	36.1	36.3	36.4	36.7	36.9	37.1	37.3
1.029	36.5	36.5	36.5	36.7	36.7	36.8	36.8	36.9	37.1	37.2	37.5	37.6	37.7	38	38.1	38.4	38.6
1.03	37.7	37.8	37.8	37.8	38	38	38.1	38.2	38.4	38.5	38.6	38.9	39	39.3	39.4	39.7	39.9
1.031	39	39	39	39.1	39.1	39.3	39.4	39.5	39.7	39.8	39.9	40.2	40.3	40.6	40.7	41	41.2

Table HY-SA-2: Salinity (parts per thousand) as a function of specific gravity and temperature (as of 2/2002)- continued

	Temperature of Water (° C)																
Observed Reading	**15**	**16**	**17**	**18**	**18.5**	**19**	**19.5**	**20**	**20.5**	**21**	**21.5**	**22**	**22.5**	**23**	**23.5**	**24**	**24.5**
0.998																	
0.999										1.3	1.4	1.5	1.6	1.8	1.9	2	
1		1.3	1.5	1.6	1.8	1.9	2	2.1	2.3	2.4	2.5	2.7	2.8	2.9	3.1	3.2	3.3
1.001	2.3	2.5	2.8	2.9	3.1	3.2	3.3	3.4	3.6	3.7	3.8	3.8	4	4.1	4.2	4.4	4.5
1.002	3.7	3.8	4.1	4.2	4.4	4.5	4.6	4.7	4.9	5	5.1	5.3	5.4	5.5	5.7	5.9	6.1
1.003	5	5.1	5.4	5.5	5.7	5.8	5.9	6.1	6.2	6.3	6.4	6.6	6.7	6.8	7.1	7.2	7.4
1.004	6.3	6.4	6.7	6.8	7	7.1	7.2	7.4	7.5	7.6	7.7	7.9	8	8.3	8.4	8.5	8.7
1.005	7.6	7.9	8	8.3	8.4	8.4	8.5	8.7	8.8	8.9	9	9.2	9.4	9.6	9.7	9.8	10
1.006	8.9	9.2	9.3	9.6	9.7	9.8	10	10.1	10.2	10.4	10.5	10.6	10.7	10.9	11	11.1	11.4
1.007	10.2	10.5	10.6	10.9	11	11.1	11.3	11.4	11.5	11.7	11.8	11.9	12	12.2	12.3	12.6	12.7
1.008	11.5	11.8	11.9	12.2	12.3	12.4	12.6	12.7	12.8	13	13.1	13.2	13.3	13.5	13.7	13.9	14
1.009	12.8	13.1	13.2	13.5	13.6	13.7	13.9	14	14.1	14.3	14.4	14.5	14.7	14.9	15	15.2	15.3
1.01	14.1	14.4	14.5	14.8	14.9	15	15.2	15.3	15.4	15.6	15.7	15.8	16.1	16.2	16.3	16.5	16.6
1.011	15.4	15.7	15.8	16.1	16.2	16.3	16.5	16.6	16.7	16.9	17	17.3	17.4	17.5	17.6	17.8	18
1.012	16.7	17	17.1	17.4	17.5	17.6	17.8	17.9	18	18.3	18.4	18.6	18.7	18.8	19	19.2	19.3
1.013	18	18.3	18.4	18.7	18.8	19	19.1	19.2	19.3	19.6	19.7	19.9	20	20.1	20.4	20.5	20.6
1.014	19.3	19.6	19.9	20	20.1	20.3	20.4	20.6	20.8	20.9	21	21.2	21.3	21.4	21.7	21.8	21.9
1.015	20.6	20.9	21.2	21.3	21.4	21.7	21.8	21.9	22.1	22.2	22.3	22.5	22.6	22.9	23	23.1	23.3
1.016	21.9	22.2	22.5	22.6	22.7	23	23.1	23.3	23.4	23.5	23.6	23.8	24	24.2	24.3	24.6	24.7
1.017	23.3	23.5	23.8	24	24.2	24.3	24.4	24.6	24.7	24.8	24.9	25.1	25.3	25.5	25.6	25.9	26
1.018	24.6	24.8	25.1	25.3	25.5	25.6	25.7	25.9	26	26.1	26.2	26.5	26.6	26.8	26.9	27.2	27.3
1.019	25.9	26.1	26.4	26.6	26.8	26.9	27	27.2	27.3	27.4	27.7	27.8	27.9	28.1	28.3	28.5	28.6
1.02	27.2	27.4	27.7	27.9	28.1	28.2	28.3	28.5	28.6	28.7	29	29.1	29.2	29.5	29.6	29.8	29.9
1.021	28.5	28.7	29	29.2	29.4	29.5	29.6	29.8	29.9	30.2	30.3	30.4	30.5	30.8	30.9	31.1	31.3
1.022	29.8	30	30.3	30.5	30.7	30.8	30.9	31.1	31.3	31.5	31.6	31.7	32	32.1	32.2	32.5	32.6
1.023	31.1	31.3	31.6	31.9	32	32.1	32.2	32.5	32.6	32.8	32.9	33	33.3	33.4	33.5	33.8	33.9
1.024	32.4	32.6	32.9	33.2	33.3	33.4	33.5	33.8	33.9	34.1	34.2	34.5	34.6	34.7	35	35.1	35.2
1.025	33.7	33.9	34.2	34.5	34.6	34.7	35	35.1	35.2	35.4	35.5	35.8	35.9	36	36.3	36.4	36.5
1.026	35	35.2	35.5	35.8	35.9	36	36.3	36.4	36.5	36.7	36.9	37.1	37.2	37.3	37.6	37.7	38
1.027	36.3	36.5	36.8	37.1	37.2	37.5	37.6	37.7	37.8	38	38.2	38.4	38.5	38.8	38.9	39.1	39.3
1.028	37.6	37.8	38.1	38.4	38.5	38.8	38.9	39	39.1	39.4	39.5	39.7	39.8	40.1	40.2	40.4	40.6
1.029	38.9	39.1	39.4	39.7	39.9	40.1	40.2	40.3	40.4	40.7	40.8	41	41.2	41.4	41.5	41.8	41.9
1.03	40.2	40.4	40.7	41	41.2	41.4	41.5	41.6	41.9	42	42.1	42.3	42.5	42.7	42.9	43.1	43.2
1.031	41.5	41.8	42	42.3	42.5	42.7	42.8	43.1	43.2	43.3	43.4	43.6	43.8				

Table HY-SA-2: Salinity (parts per thousand) as a function of specific gravity and temperature (as of 2/2002)- continued

	Temperature of Water (° C)																
Observed Reading	**25**	**25.5**	**26**	**26.5**	**27**	**27.5**	**28**	**28.5**	**29**	**29.5**	**30**	**30.5**	**31**	**31.5**	**32**	**32.5**	**33**
0.998			1.4	1.5	1.6	1.9	2	2.1	2.4	2.5	2.8	2.9	3.2	3.3	3.6	3.7	
0.999	2.1	2.3	2.5	2.7	2.8	3.1	3.2	3.3	3.6	3.7	3.8	4.1	4.2	4.5	4.7	4.9	5.1
1	3.4	3.7	3.8	4	4.2	4.4	4.5	4.7	4.9	5	5.3	5.4	5.7	5.8	6.1	6.2	6.4
1.001	4.7	4.9	5.1	5.3	5.5	5.7	5.8	6.1	6.2	6.4	6.4	6.7	6.8	7.1	7.2	7.5	7.7
1.002	6.2	6.3	6.4	6.7	6.8	7	7.2	7.4	7.6	7.7	7.9	8.1	8.3	8.5	8.8	8.9	9.2
1.003	7.5	7.6	7.9	8	8.1	8.4	8.5	8.7	8.9	9	9.3	9.4	9.7	9.8	10.1	10.4	10.5
1.004	8.8	9	9.2	9.3	9.6	9.7	9.8	10.1	10.2	10.5	10.6	10.9	11	11.3	11.4	11.7	11.8
1.005	10.2	10.4	10.5	10.6	10.9	11	11.3	11.4	11.5	11.8	11.9	12.2	12.3	12.6	12.8	13	13.2
1.006	11.5	11.7	11.8	12	12.2	12.3	12.6	12.7	13	13.1	13.3	13.5	13.7	13.9	14.1	14.4	14.5
1.007	12.8	13	13.2	13.3	13.5	13.7	13.9	14.1	14.3	14.4	14.7	14.9	15	15.3	15.4	15.7	16
1.008	14.1	14.3	14.5	14.7	14.9	15	15.2	15.4	15.6	15.8	16	16.2	16.5	16.6	16.9	17	17.3
1.009	15.4	15.7	15.8	16	16.2	16.3	16.6	16.7	17	17.1	17.4	17.5	17.8	17.9	18.2	18.4	18.6
1.01	16.9	17	17.1	17.4	17.5	17.8	17.9	18	18.3	18.4	18.7	18.8	19.1	19.3	19.5	19.7	20
1.011	18.2	18.3	18.6	18.7	18.8	19.1	19.2	19.5	19.6	19.9	20	20.3	20.4	20.6	20.9	21	21.3
1.012	19.5	19.6	19.9	20	20.3	20.4	20.6	20.8	20.9	21.2	21.4	21.6	21.8	21.9	22.2	22.5	22.6
1.013	20.8	21	21.2	21.3	21.6	21.7	21.9	22.1	22.3	22.5	22.7	22.9	23.1	23.4	23.5	23.8	24
1.014	22.2	22.3	22.5	22.7	22.9	23.1	23.3	23.5	23.6	23.9	24	24.3	24.4	24.7	24.9	25.1	25.3
1.015	23.5	23.6	23.8	24	24.2	24.4	24.6	24.8	24.9	25.2	25.3	25.6	25.9	26	26.2	26.5	26.6
1.016	24.8	24.9	25.2	25.3	25.6	25.7	26	26.1	26.4	26.5	26.8	26.9	27.2	27.4	27.6	27.8	28.1
1.017	26.1	26.4	26.5	26.6	26.9	27	27.3	27.4	27.7	27.8	28.1	28.3	28.5	28.7	29	29.1	29.4
1.018	27.4	27.7	27.8	28.1	28.2	28.5	28.6	28.9	29	29.2	29.4	29.6	29.8	30	30.3	30.5	30.7
1.019	28.9	29	29.1	29.4	29.5	29.8	29.9	30.2	30.3	30.5	30.8	30.9	31.2	31.3	31.6	31.9	32.1
1.02	30.2	30.3	30.5	30.7	30.9	31.1	31.3	31.5	31.7	31.9	32.1	32.2	32.5	32.8	32.9	33.2	33.4
1.021	31.5	31.6	31.9	32	32.2	32.4	32.6	32.8	33	33.3	33.4	33.7	33.8	34.1	34.3	34.6	34.7
1.022	32.8	33	33.2	33.3	33.5	33.8	33.9	34.2	34.3	34.6	34.7	35	35.2	35.4	35.6	35.9	36.1
1.023	34.1	34.3	34.5	34.7	34.8	35.1	35.2	35.5	35.8	35.9	36.1	36.3	36.5	36.8	36.9	37.2	37.5
1.024	35.5	35.6	35.8	36	36.3	36.4	36.7	36.8	37.1	37.2	37.5	37.7	37.8	38.1	38.4	38.5	38.8
1.025	36.8	36.9	37.2	37.3	37.6	37.7	38	38.1	38.4	38.5	38.8	39	39.1	39.4	39.7	39.9	40.1
1.026	38.1	38.2	38.5	38.6	38.9	39	39.3	39.5	39.7	39.9	40.1	40.3	40.6	40.7	41	41.2	41.5
1.027	39.4	39.7	39.8	40.1	40.2	40.4	40.6	40.8	41.1	41.2	41.5	41.6	41.9	42.1	42.3	42.5	42.8
1.028	40.7	41	41.1	41.4	41.5	41.8	42	42.1	42.4	42.5	42.8						
1.029	42.1	42.3	42.5	42.7	42.9	43.1											

Chapter VI

LAND COVER/BIOLOGY INVESTIGATION

GLOBE Measurements

What Measurements (basic) are taken?

- **Land Cover Sample Site Protocol**
- **Biometry Protocol**
  - *Canopy and Ground Cover,*
  - *Tree shrub and/or Graminoid height*
  - *Tree Circumference*
- **Manual Land cover Mapping Protocol**

Where is Measurements Taken?

These investigations are carried out at the Land cover study site in your GLOBE Study Site, 15 km by 15 km area centered around your school. These sample sites will serve as a location where you can take land cover measurements. These measurements are needed to create land cover type map.

All Land Cover sample sites within the Globe study site must have the following characteristics

1. Homogeneous - The same MUC class throughout
2. 90 m X 90 m in size.
3. Oriented in the cardinal directions

All land cover sample sites are visited at least once but can be visited multiple times during different times of the year or different years , in order to conduct studies in biomass overtime.

The goals of Land Cover / Biology Investigation are threefold:

- To take detailed measurements at selected site within the entire GLOBE Study Site. These measurements are used by scientists to study vegetation growth and changes and to verify maps made from remotely sensed data.
- To make observations at many sub-areas within the entire study site. These observations are used by scientists to validate land cover maps generated from remotely sensed data.
- To create a land cover map of your entire study area. This map will be used in learning more about your surroundings by making observations and measurements at selected sample locations.

How to Layout a Land Cover Sample Site?

Select a 90 m X 90 m homogeneous area. Use your landsat TM image and/or your local knowledge to help you locate candidate sites.

In order to determine if your site is at least 90 m X 90 m in the cardinal directions, pace 90 metres from one of the corners of the site. Pace in two directions either North or South AND either East or West. This will give you an estimate of where two more corners are. Estimate the location of the fourth corner. If the entire area is homogeneous, the site is appropriate.

How to take Biometry measurements?

Once you have established that the site is a 90 m X 90 m homogeneous are aligned in the cardinal directions (N, S, E and W), You need to determine its MUC level 1 Class. Biometry measurements are taken in the centre 30 m X 30 m pixel of the 90 m X 90 m land cover sample site.

Take Biometry measurements following the Biometry Protocol. This will involve doing the following:

- Mark the center of the 90 in x 90 m site where you will be taking measurements.
- Divide the students into four groups.
- Assign each group a direction to walk and take canopy and ground cover
- measurements along a diagonal from the center using a compass, assign each group one of the following directions: NE (45^0)SE (135^0)SW (225^0) and NW (315^0).

- Each diagonal measures 42.4 in, each group should walk half of a diagonal or 21.2 mts.
- If you choose, put markers at each comer.
- Combine the data from each group in order to choose your final MUC class, and submit the data to GLOBE.

Special Considerations for Biology Study Sites

The only difference between your Biology Study Site and the Central 30m × 30m areas of other Quantitative Land Cover Sample Sites is that biometry measurements are repeated periodically at the study site while at sample sites observations are made just once. After identifying the dominant and co-dominant vegetation types, you will perform a series of biometry measurements over time.

Step 1: Establish Your Biology Study Site

- Follow step 1 through 4 of the Quantitative Land Cover Sample Site protocol. Make sure this site is a MUC level 1 class 0, 1 or 4 area.

Step 2: Establish and Mark Your 30m × 30m Biology Study Area

- Place a marker where you want one corner of your 30m × 30m square to be
- Use your compass and measuring tape to move 30 meters in a cardinal direction. Place a second marker at the end of this transect. This forms side one.
- From the second marker, move 30-meter perpendicular to side one. Place a third marker at the end of this transect. This forms side two.
- From the third marker, move 30 meters perpendicular to side two and parallel to side one. Place a fourth marker at the end of this transect. This forms side three.
- From the fourth marker, move 30 meters toward your original marker. If this transects ends within 2 to 3 meters of the original marker, you are successful. If you are farther off the mark, check your compass heading for each side check the length of each side, and try again.
- Establish the center of your square by passing the diagonal transects of the square and placing a marker where the two paths intersect. You may use string to make these diagonals.

Making Biometry Measurements

Depending on the types of vegetation at your site, you and your students will make biometry measurements on canopy cover, ground cover, and tree height and circumference and grass biomass.

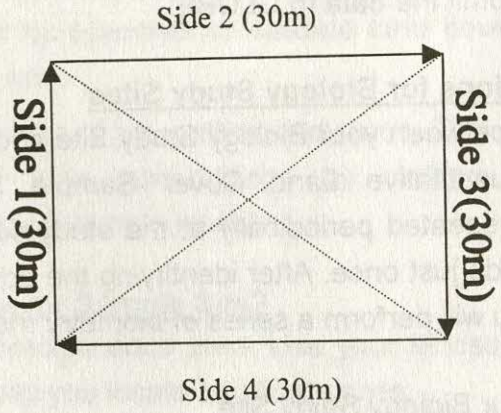


Figure LAND – P – 9 – Biology Study Site Set Up

When to Make Biometry Measurements

At your Biology Study Site make biometry measurement twice each year – once during peak growing season and one during the least active season. If you have no temperature or rainfall – dependent seasonally in your region, take measurements only once a year.

At all other Quantitative Land Cover Sample Sites: perform biometry measurements just once, as close to the peak of the growing season as possible.

Investigation Instruments

1. The MUC System

The GLOBE program uses MUC (Modified UNESCO Classification Systems) as an ecological classification system, which follows international standards and ecological terminology for the identification of specific land cover classes. By using a standard international classification system, all the GLOBE data may be compiled into a single regional or global land cover data set.

There are two components of the MUC system.

- Part one is the outline of the classification system, containing the hierarchical list of labels for every class.
- Part two is the glossary, with rules and definition. Before classifying any Land Cover type, it is crucial to always check the definition of the particular land cover class you believe is appropriate.

MUC has a hierarchical, or tree structure, with ten level 1 classes. These classes are very general and easily identified.

You must select one unique MUC class to identify a land cover type at each MUC level, beginning at level 1.

Within each level 1 class there are two to six more detailed level 2 classes. Level 2 classes are still quite general and easily distinguished, level 3 and 4 are more specific communities or vegetative associations.

In order to conduct the Land Cover / Biology Investigation, it is necessary first to identify the level 1 MUC class for each Land Cover Sample Site. Each Level 1 Class is general and can be ground covered by the land cover present at the sample site. Table LAND – P – 1 shows the 10 level 1 MUC classes. All MUC level 1 classes are determined by the percentage of the total sample area covered by the dominant land cover type.

Table- LAND – P –1

MUC Code	**MUC Level 1 Classes**	**Coverage Required**
0	Forest	> 40% trees, 5 meters tall, crowns interlocking
1	Woodland	> 40% trees, 5 meters tall, crowns not interlocking
2	Shrub land	> 40% shrubs, under 0.5 to 5 meters tall
3	Dwarf shrub land	> 40% shrubs, under 0.5 meters tall
4	Herbaceous Vegetation	> 60% herbaceous plants, grasses and broad leafed plant (forbs)
5	Barren	< 405 vegetative cover
6	Wetland	> 40% vegetative cover, includes marshes swamps, bogs
7	Wetland	> 40% vegetative cover, includes marshes swamps, bogs
8	Open water	> 60% open water
9	Cultivated land	> 60% non-native cultivated species
10	Urban	> 40% urban land cover (buildings)

Identify MUC level 1 Class

1. Select an area of homogeneous land cover as your Land Cover Sample Site.
2. Visually estimate the percent of the ground covered by the dominant land cover.
3. Review MUC level 1-class definitions to be sure students understand them.
4. Proceed with the steps of how to classify land cover sample sites to MUC level 1 given in the MUC System Protocol.

Once you have established the level 1 MUC class of a Land Cover Sample Site, you are ready to proceed with one of the Land Cover Sample Site Protocols.

2. Densiometer

A densiometer is an instrument used for taking measurements of canopy cover as part of the biometry measurements described in the biometry protocol.

How to Make a Densiometer?

1. Take a tube approximately 4cm in diameter and 7.5cm long attach two strings and form a crosshair.
2. Attach an 18cm piece of string with a metal mat or washer hanging loosely from it across the diameter of other end of the tube. You have made a densiometer.

How to use a densiometer?

1. Look up through the densiometer, making sure the densiometer is vertical and the metal nut/ washer is directly below the intersection of the crosshairs at the top of the tube.

Note: Only use the densiometer for looking UP at the canopy cover. Do not use it for looking DOWN at ground cover.

2. If you see vegetation, twigs, or branches touching the crosshair intersection, you would call this "T" meaning that there is tree canopy or "SB" meaning that there is shrub canopy
3. If you do not see vegetation, twigs, or branches touch the crosshair intersection, you would call this minus "-" meaning that you saw the sky above the intersection of the crosshairs.

3. Clinometer

A Clinometer is an instrument used for measuring angles. In GLOBE, you use it to find the angle for calculating tree heights. It is also used to determine obstacles at an atmosphere study site. The calculations work by applying the principles based on the properties of right triangles.

A Clinometer measures angles to determine the heights of objects without directly measuring them. The clinometer has an arc with graduate degree markings that go from 0 to 90 degrees. (See Figure LAND – P – 13) When you site an object through the clinometer's drinking straw, you can read the number of degrees of angle BVW by noting where the string touches the arc. Angle BVW is equal to angle BAC, which is the angle of elevation of the clinometer. If you know both the angles of elevation and your distance away from an object, you can calculate the height of that object using a simple equation.

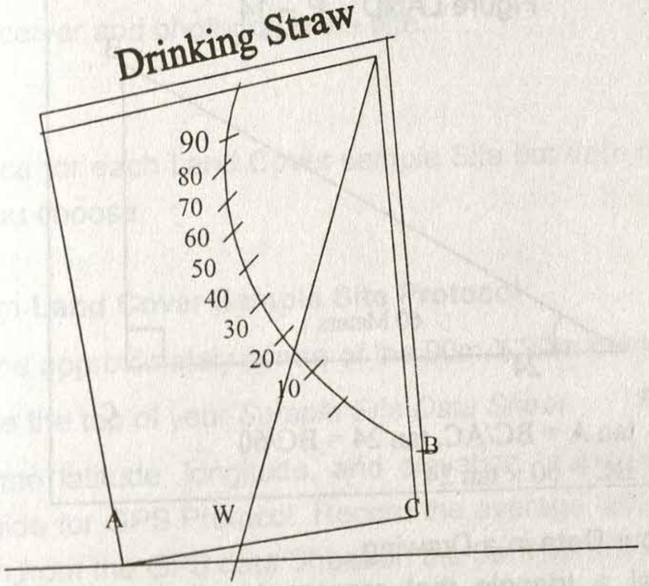


Figure LAND – P – 13

How to make clinometers?

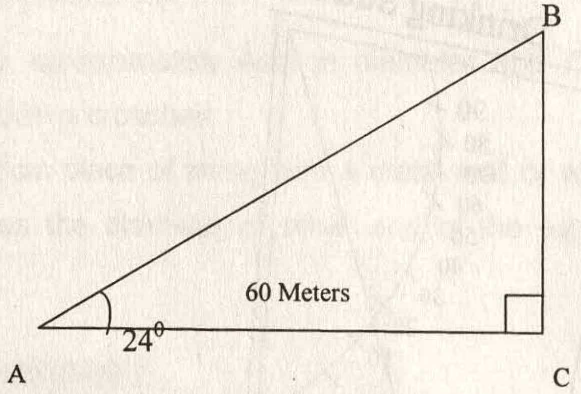
Step 1: Make a Clinometer

1. Glue a copy of the Clinometer Sheet in the Appendix onto a same size piece of stiff cardboard.
2. Punch a hole through the marked circle on the sheet and tie one end of a 15cm piece of string through it.
3. Tie a metal nut or washer to the other end of the string.
4. Tape a drinking straw along the designated line on the sheet, to use a site.

Step 2: Measure and Record the Distances and Angles Needed to Determine tree Height

1. At one of your selected trees, move a predetermined distance away from the base of the tree and record the distance. This is your line AC. See figure LAND – P – 14. For the most accurate results you should adjust your distance away from the base of the tree so that Angle BVW is between 30 degrees and 60 degrees.
2. Measure and record the height of your eye above the ground.
3. Site the top of the tree through the drinking straw on the clinometer.
4. Record the number of degrees in angle BVW on the clinometer, this tells you the number of degrees in angle BAC.

Figure LAND – P – 14



tan A = BC/AC, tan 24 = BC/60
BC = 60 × tan 24

Step 3: Organize your Data in a Drawing

1. Draw and label a triangle that represents all the information you have accumulated.

Step 4: Calculate Tree Height

1. Use your Table of Tangents and the following equation to solve for the height of BC

$$BC = 60 \times \tan 24$$
$$= 60 \times (0.45) \quad = 27m$$

2. Add the height of BC to the height of the clinometer from the ground (your eye level) to get the total height of the tree. In the above example the height of the tree is 27 + 1.5m = 28.5m

Step 5: Repeat the Above Process for All Selected Trees

Step 6: Calculate and Record Average Tree Height

LAND COVER PROTOCOLS

Land cover Sample Site Protocol

Purpose

To determine the major land cover type at a Land Cover sample Site.

Overview

Students classify a homogenous land cover site by virtually examining the site. If necessary, students take biometry measurements following the Biometry Protocol to support their choice of MUC classification. Students locate the site using a GPS receiver and photograph the site.

Frequency

Collect data once for each Land Cover sample Site but data can be collected as frequently as you choose.

How to Perform Land Cover Sample Site Protocol

1. Locate the approximately centre of the 90m X 90m homogenous site.
2. Complete the top of your *Sample Site Data Sheet.*
3. Identify the latitude, longitude, and elevation of the centre following the Field Guide for GPS Protocol. Record the average latitude, longitude, and elevation from the GPS data Sheet on the Sample Site Data Sheet.
4. Determine MUC class to the most detailed level using either the MUC field guide or the MUC system table in combination with the MUC glossary of terms. Take any measurements necessary following the Field Guides for biometry protocol to help determine the class.
5. Note any unusual or helpful metadata. Record this in the appropriate place on your *Sample Site Data Sheet.*
6. Using the camera, take a photo in each cardinal direction- North, South, East, and West. Use your compass to determine the directions.

Biometry Protocol

Purpose

To measure and classify the plant life present at a land cover sample site to help determine the MUC classification.

Overview

Students walk the half diagonals of their Land Cover sample site and take one or more biometry measurements. These may include canopy cover and Ground cover, Identifying dominant and co-dominant vegetation species, and measuring tree circumference and height.

Frequency

As necessary to determine MUC at most site, or , frequently as an enrichment study

1. CANOPY COVER AND GROUND COVER

How to Measure Canopy and Ground Cover

1. Locate the center of your homogeneous Land Cover Sample Site. This is your starting point.
2. Choose a direction in which to walk: NE, NW, SE, or SW. Use a compass for bearing.
3. Look up through your densiometer. Be sure the metal nut or washer is directly below the crosshairs at the top of the tube. in column I of the Canopy and Ground Cover Data Sheet record: if you see sky above the crosshairs
4. "T" if you see leaves, twigs, or branches at the crosshairs and they are attached to a tree (greater than 5 meters tall)
5. "SB" if you see leaves, twigs or branches at the crosshairs and they are attached to a shrub (a woody plant between 50 cm and 5 meters tall)
6. In column 2 of the Canopy and Ground Cover Data Sheet record: if you see sky above the crosshairs "E" if the tree or shrub you see is evergreen "D" if the tree or shrub you see is deciduous
7. Stand with your feet shoulder-width apart. Look down and observe any vegetation that is touching your feet or legs below the knee'. In column 3 of the Canopy and Ground Cover Data Sheet record: if there is no vegetation

"B" if there is brown vegetation (still attached to the ground) "G" if there is green vegetation and in column 4 identify the type of green vegetation

8. In column 5 of the Canopy and Ground Cover Data Sheet record the species name or common name of the tallest tree or shrub you have observed at this spot.
9. In column 6 of the Canopy and Ground Cover Data Sheet record: 11+" if the tallest vegetation is a shrub "-" if the tallest vegetation is not a shrub
10. In column 7 of the Canopy and Ground Cover Data Sheet record: "+"if the tallest vegetation is a dwarf shrub if the tallest vegetation is not a dwarf shrub
11. Take a pace (two steps) in the direction you are going. Repeat steps 3 to 8. Stop when you have gone 21.2 meters and reached the corner of your sample area.
12. Repeat steps 2 to 9 for another direction until all four are measured or share your data with other students who have paced the other diagonals of your sample area.
13. Complete the tables at the bottom of page 2 of the Canopy and Ground Cover Data Sheet using the total data collected from all four diagonals. Calculate the percentages indicated.
14. Use these data to help determine or confirm your choice of a MUC classification and to determine dominate and co-dominant species for your site. Report these data to GLOBE.

2. GRAMINOID, TREE, AND SHRUB HEIGHT PROTOCOL

How to Measure the Height of the Graminoid, Tree and Shrub Height?

How to choose which trees to Measure

1. If the dominant species on your site is a tree, select five specimens of the tree. Include the largest tree, the smallest tree that still reaches the canopy, and three intermediate trees. Mark the trees for future reference.
2. If you have a co-dominant tree species, repeat the process. If there are fewer than five co-dominant species trees, include other tree species to make a total of five. Mark the tree for future reference.

In the Field

1. Measuring Graminoid Vegetation Height (Graminoids are grass-like species.)

Stand in the center of your Land Cover Sample Site and blindfold your partner. Have him or her throw a beanbag somewhere in the site.

- Using the flexible measuring tape, measure the height of the herbaceous vegetation where the beanbag landed. Measure from the ground to the top of the graminoids.
- Record the height on the Graminoid, Tree, and Shrub Height. Data Sheet,
- Repeat this process two more times and average the results.
- Use this average to determine your MUC class.

2. Measuring Shrub Height (Shrubs are 0.5 m to 5.0 m tall.)
   - Stand in the center of your Land Cover Sample Site and blindfold your partner. Have him or her throw a beanbag somewhere in the site.
   - Locate the closest shrub to the beanbag. Measure the height of the shrub from the ground to the tallest branch. Do this with a tape measure if possible. if the shrub is too tall, measure it with your Clinometer using the directions for Measuring Tree Height in the next section.
   - Record the height on the Graminoid, Tree, and Shrub Height Data Sheet.
   - Repeat this process two more times and average the results.
   - Use this average to determine your MUC class.
3. Measuring Tree Height (Hint: Trees are greater than 5.0 m tall.)
   - Determine your dominant (most common) and co-dominant (second-most common) tree species by counting the number of times each tree species was recorded on the Canopy and Ground Cover Data Sheet. Record the names of the species on your Graminoid, Tree and Shrub Height Data Sheet.
   - Choose:
     - the tallest tree of the dominant species
     - the shortest tree of the dominant species that still reaches the canopy

  - three trees that have heights in between the tallest and shortest of the dominant species

- Permanently mark and number/label the trees if you will be returning to this site to take measurements over time.
- Measure the height of the tree using the clinometer. If you are on ground with a slope, or using the simplified clinometer technique, then use the appropriate Alternative Technique to Measure Tree Height Field Guide to substitute for the steps below. Otherwise,
  - move away from the base of the tree until you can see the top of the tree through the drinking straw of the clinometer.
  - For the best results, adjust your distance from the base of the tree so that the clinometer reads as close to 30* as possible and you are at least as far from the tree as it is tall.
  - Be sure to be on level ground so that your feet are at the same elevation as the base of the tree. Remember, if you are not on the same level with the tree, you need to use an Alternative Technique to Measure Tree Height Field Guide.
  - Have your partner read and record the number of degrees (0 of the angle.
  - Using the Table of Tangents, record the TAN of the angle on the Data Sheet.
  - Measure the distance between you and the tree. Have your partner help you using the 50 m tape. Record this in the table on your Data Sheet.
  - Measure the height from the ground to your eye level. (You only need to do this step once!) Record this in the table.
  - Calculate the tree height using the following formula:

Height of Tree = TAN (angle of clinometer) x (distance to tree) + eye height and record on your Data Sheet.

Measure the height of each tree three times and calculate the average of the three heights. if they are within one meter, record the average on your Data Sheet. If not, repeat the measurements until they are within one meter.

- Repeat the step above for the other four trees.

- If your co-dominant species is a tree, repeat steps b-e for the co-dominant tree species. If you do not have five co-dominant species trees on your site, include other tree species to make a total of five. Note that you are using other species in the Metadata.

Simplified Clinometer Technique

In the Field

1. Work in a team of two or three. Move away from the base of the tree until the clinometer reads 45 degrees when you see the top of the tree through the straw.
2. Have your partner stretch the 50 m measuring tape from the base of the tree to your toes. Your partner should then step on the tape at the ground and then run it up to your eye level.
3. This is the height of the tree. Record this on the Measure Tree Height on Level Ground: Simplified Clinometer Technique Data Sheet.
4. Repeat steps 1-3 two more times for each tree and report the average value.

3. TREE CIRCUMFERENCE

How to Measure Tree Circumference?

1. With the flexible tape measure, measure from the ground at the base of the tree to a height of 1.35 m up on the tree (called Breast Height).
2. Measure the circumference in centimeters at Breast Height.
3. Record this on the Tree Circumference Data Sheet.
4. Repeat this for each of the trees you measured for height,

4. DOMINANT AND CO-DOMINANT VEGETATION

Students will now identify the most common (dominant) and second most common (co-dominant) vegetation types on your Biology Study Site or other Quantitative Land Cover Sample Sites. For closed Forest and Woodland sites, identify the scientific names of the two types of trees that have the most canopy coverage. For herbaceous sites, identify the plants that cover the most ground as graminoid (grass) or forb (broad level).

Step 1: Identify Vegetation Types

- Repeat the Canopy cover and ground cover measurements given above but this time the students identifies each tree species that touches the crosshair. The student also looks at the ground and identifies any vegetation type underfoot or touching her foot or leg.

If you cannot identify the genus and species of a tree in the field, record the common tree name, if known, describe the tree weil so that you can accurately identify it later.

Step 2: Calculate which Vegetation Types are Dominant and which are Co-dominant.

- Tabulate your results
- If tree canopy cover is 40% or greater and the canopy is above 5m in height, then your site is Forest or Woodland. The dominant vegetation is the tree species seen the most times through the densiometer. The co-dominant vegetation is the tree species seen the second most times. If your site is forest or woodland, identify the tree species using dichotomus keys or by consulting local experts.
- If tree canopy cover is less than 40% and your ground cover is more than 60% then your site is dominant by herbaceous vegetation. Identify dominant and co-dominant species.

Step 3: Record Your Findings

- If your site is Forest or Woodland enter the first four letters of the genus and species for both the dominant and co-dominant tree species in the proper space on your work sheet.
- If your site is Herbaceous Vegetation, enter either "GRAM", for grass (graminoid), or "FORB" for other, broad leaved vegetation in the proper space on your Data Work Sheet.

If the vegetation on your site is diverse it may be difficult to identify the dominant and co-dominant vegetation. If two types are not clearly dominant and co-dominant, describe the vegetation types well in the Notes section of your Dominant / Co-dominant Vegetation Field Data Work Sheet. Enter mixed on the Dominant / Co-dominant line.

How to Use Dichotomous Keys

A dichotomous key is a branching decoder, which works into two approximately equal and contradictory divisions that lead to only one correct outcome. To use a dichotomous key we, too must choose correctly between two options in a series of contradictory options.

Manual Land Cover Mapping Protocol

Purpose

To produce a land Cover type map of the 15 km X 15 Km Globe Study Site from hard Copies of Land Sat satellite Images

Overview

Students place clear transparencies over the landsat TM images and use markers to outline and classify area of different land Cover using the MUC system

Frequency

One time But may be in iterative process as you progressively investigate more areas with in your GLOBE study sites.

How to Create a Land Cover Type Map

1. Tape a blank transparency sheet over the false-color infrared satellite image.
2. Mark the corners of the satellite image and label the top of the image on your blank transparency. If it moves, you can put it back where it belongs using these marked comers. This will also allow you to move the transparency to the true-color image.
3. Outline areas of similar land cover using the markers. If you have enough colors, use a different color to represent each area that you feel is a distinctive land cover type.
4. Assign each area a MUC class from the MUC Field Guide or MUC System Table and MUC Glossary of Terms, using your knowledge of the area.
5. If you cannot label an area, discuss the best possible choice of land cover type with your classmates or ask a person in your class who lives near the area to visit it on their way to or from school.
6. if there are any areas left to identify, visit the site and perform the Land Cover Sample Site Protocol.

7. Label the map completely It may help to place the transparency on a blank, white sheet of paper to check for unlabeled areas.

See your teacher for instructions on how to submit your map to GLOBE.

Some hints to help with false-colour infrared TM images:
Red represents actively growing green vegetation (pink areas often represent grasslands, bright red represents hardwoods and fields, dark red represents evergreens). Black represents water or a cloud shadow. Blue-white represents urban areas, exposed rock, sand, and bare soils.

Qualitative and Quantitative Land Cover Sample Sites and their use in Land Cover Mapping

How to Enter Your Observations on the Land Cover/Biology Investigation Field Data Work Sheet

Data Work Sheet

Students should record the following data and information on the Land Cover / Biology Investigation Field Data Work Sheet.

- Site Identification
- Site Name
- Country / State / City
- GPS Location
- Data and Time
- Recorded by
- MUC Land Cover Classes 2, 3 and 4
- Dominant and Co-dominant Species
- Biometry Summary
- Canopy Cover
- Ground Cover
- Number, Height and Circumference of Trees
- Green / Brown Biomass
- Photographs

MUC SYSTEM PROTOCOL

Purpose

To classify Land Cover using the Modified UNESCO Classification (MUC) system.

Overview

Students will learn how to use this hierarchical classification system to assign a MUC class to their Land Cover Sample Sites.

Frequency

For land cover sample sites. Determine MUC class once during peak foliage.

Materials and Tools

MUC system and definitions, Compass, Tubular densiometer, Biometry Data Work Sheet.

Introduction

In GLOBE, we use the Modified UNESCO classification (MUC) system for classifying land Cover MUC has an ecological basis and follows international standards. The MUC system has four level of classification arranged hierarchically. Each higher level is based on more detailed properties of Land Cover.

A classification system is a comprehensive set of categories, with labels and definitions, typically arranged in a hierarchy or branching structure. A classification system is used to organize a set of data such as an inventory of land cover types, into meaningful groups. The classification system must be both totally exhaustive and mutually exclusive. A totally exhaustive classification has an appropriate class for every passable data point (e.g. land cover type). A mutually exclusive classification has one and only one appropriate class for every data point.

An example of Determining MUC Class to Level 2

The criteria used to distinguish between Forest and Woodland Classes at MUC level 1 criteria used to distinguish between Mainly Deciduous, Mainly Evergreen and mainly Xeromorphic cover type at level 2.

How to classify Land Cover using the MUC System

When classifying Land Cover using the MUC system always begin with the most general classes (level1) and proceed sequentially to the more detailed (higher level) classes.

Step 1: Eliminate as many MUC level 1 Classes as possible

- Compare the Land Cover Sample Site with the definitions of the 10MUC level 1 classes.
- Usually there are only a few level 1 classes that can possible match your site, eliminate the others from consideration.

Step 2: Make any measurements necessary to determine the MUC level 1 Class

- Perform measurements of tree height, canopy cover or ground cover and identify dominant and co-dominant species as necessary to distinguish between different MUC level 1 classes. Follow the appropriate portions of the Biometry Protocol. In many cases no measurements will be necessary.
- Using the quantitative measurements, resolve any questions and assign a MUC level 1 class to this site.

Step 3: Check your assignment

Read the definitions for the MUC levels 2, 3 and 4 for your chosen MUC level 1 class that is possible for your area. If none of the definitions of higher level MUC classes match your site reconsider your choice of MUC Level 1 class in step 2.

How to Classify Land Cover Sample to MUC levels 2, 3 and 4

Step 1: Determine the MUC level 2 class

- Review the level 2 definitions that apply to MUC level / class of your site.
- Select the MUC level 2 class that applies to your site.
- If necessary, make measurements of the vegetation on your site to resolve quantitative destinations between different level 2 classes using the procedures given in using field observations to determine MUC class.

Step 2: Determine the MUC level 3 class

- Review the level 3 definitions that apply to the MUC level 2 class of your site. If there are none, record your MUC level 2 class you have completed this protocol
- Select the MUC level 3 class that applies to your site

Step 3: Determine the MUC level 4 class

- Review the level 4 definitions that apply to the MUC level 3 Class of your site. If there are none record your MUC level 3 class, you have completed this protocol.
- Select the MUC level 4 class that applies to your site.

Using Field Observations to Determine MUC class

Distinguishing among some MUC classes requires quantitative measurements of the percentage of your site that is covered by different types of vegetation types observed at the Land Cover Sample Site.

Determining the Percentage of Tree Cover that is Evergreen or Deciduous

Step 1: Make a modified canopy cover measurement

- Repeat that canopy cover measurement from the Biometry protocol but at each location not "E" if the canopy touching the crosshairs is part of an evergreen tree and "D" if the canopy touching the crosshairs is part of a deciduous tree.

Step 2: Calculate the percentage of the canopy that is evergreen or deciduous

- Divide the number of E observations (or D observations) by the sum of the E's and the D's and multiply by 100 if the percentage of evergreen species is greater than 50% then the site is considered mainly evergreen.

Determining the Composition of Herbaceous Coverage

Step 1: Make a modified measurement of ground cover

- Repeat the ground cover measurement from the Biometry Protocol, if the vegetation under foot or touching the ankle or leg below the knee is a graminoid record "GD" and an "FB" if it is forb.

Step 2: Calculate the percentage of ground cover that is graminoid or forb

- Divide the number of GD measurements (or FB measurements) by the sum of the sum of the GD's and FB's and multiply by 100 to obtain a percentage. If the percentage of graminoid species is greater than 50% then the sample is considered graminoid. Conversely, if the percentage of forb is greater than 50% then the sample is considered forb.

Determining Total Shrub Canopy Cover

If your site or area is one where the dominant land cover types is naturally occurring shrubland or dwarf shrubland, you should slightly modify one of the preceding procedures.

Step 1: Determining the Amount of Shrub Cover

- If the canopy of the shrub cover is over head, carryout the canopy cover measurement from the Biometry Protocol. If the canopy cover touching the crosshairs is shrub record "SB" if it is a deciduous tree record "D", and if it is an evergreen tree record "E". If the shrubs are too short to make true canopy observations, treat the shrubs as an additional ground cover category along with graminoid and forb.

Carry out the ground cover measurement from the biometry protocol, recording "GD" if the vegetation touching the observer's body at any height is a graminoid, "FB" if the vegetation is a forb and "SB" if it is a shrub.

Step 2: Calculate the Percentage of Shrub cover

- If the shrub cover is overhead, divide the number of SB measurements by the sum of the SB, D and E measurements. If the shrubs are not overhead, divide the number of SB measurements by the sum of the SB, GD and FB measurements. Multiply by 100 to obtain a percentage.

ACCURACY ASSESSMENT PROTOCOL

Purpose

To quantitatively assess the accuracy of land cover map.

To identify the types of errors that occur on a land cover map.

Overview

Students will perform an accuracy assessment on the land cover map they have generated either by manually interpreting that or unsupervised clustering of the Land sat Thematic Mapper image of their GLOBE Study Site. Validation data collected at various Land Cover Sample Sites, which were not used in the development of the map, will be used to compare with the Land Cover map, and a difference / error matrix will be generated.

Materials and Tools

Natural colour hard copy TM image of your 15km × 15km GLOBE Study Site. False colour infra-set, hand copy TM image of your 15km × 15km GLOBE Study Site, MUC classification work sheet difference / error matrix work sheet.

Introduction

In the protocol students will assess the accuracy of the Land Cover map generated from the remotely sensed. A difference / error matrix will be generated to serve as a framework for analysing the errors which occur in the land cover map. In the case of a land cover map generated from a satellite image using unsupervised clustering, some of the errors may be related to the fundamental limitations of the satellite that image data as a tool in distinguishing land cover classes.

The following information is needed to generate a difference / error matrix.

- Land cover map generated from remotely sensed data
- Validation Land Cover Sample Sites

The difference / error matrix should have a row and column for each and every MUC class that is on the MUC classification data work sheet.

Table: Land P – 5

Sample number	Site number Student classification	on a land cover map	Validation data from land cover sample sites	√	×
1	Brown's wood	A: Mainly cold-deciduous forest with some evergreen needle leafed tree (MUC code 0222)	B: Mainly cold-deciduous forest with evergreen broad leafed trees (MUC code 0221)		×
2	Smith state park	C: Mainly evergreen woodland with rounded crowns and needled leaves (MUC code 1121)	D: Mainly evergreen woodland with rounded crowns and needled leaves (MUC code 1121)	√	
3	Apple by Form	E: Pasture (MUC code 811)	F: Pasture (MUC code 811)	√	
4	Green's woods	G: Mainly cold deciduous forest with evergreen broad leafed trees (MUC code 0221)	H: Mainly cold-deciduous forest with evergreen broad leafed trees (MUC code 0221)	√	

How to Tally Validation Data on a Difference / Error Matrix and Calculate Overall Accuracy

Step 1: Preparation

- It is important to remember not to look at what you, the student, labelled an area before going out to collect validation data for that same area knowing what the image classification says an area is before collecting the validation data based on the collection. Therefore, validation data should be collected on the Data Work Sheet and then the table given in the Land – P – 5 should be created after the data has been collected and recorded.

Step 2: Build an empty difference / error matrix

- Build an empty square matrix. There should be a column and row in the matrix for every MUC class that occurs in the validation data or on the portion of the land cover map that is being validated. Label each of the columns and rows of the matrix with one of these MUC classes. Be sure that the labels are in the same order starting from the upper left-hand corner going down and across. Be sure to include a right hand column and a bottom row for tools.

Step 3: Identify student classification from map for sample 1

- For a sample on your MUC classification work sheet look up the student MUC classification for the area of the land cover map in which this sample site is found.

Step 4: Find appropriate row in matrix for data

- Find the row in your matrix corresponding to the area of the map in which this land cover sample site is located.

Step 5: Identify MUC class from Validation data for sample

- On your MUC classification work sheet look up the validation data MUC classification for this sample site.

Step 6: Find appropriate cell in matrix for data and tally

- Move along this row from left to right to the box in the column labeled with the MUC class corresponding to that of the validation data mark one tally in this box.

Step 7: Repeat steps 3 through 6 for each sample

- Repeat this process for each sample on your MUC classification work sheet. After you have completed tallying all of the samples, calculate the totals for each row and column. If the sum of the row totals does not equal the sum of the column totals, recheck your arithmetic.

Step 8: Calculate overall accuracy

- Sum the number of tallies in all the boxes on the major diagonal of the matrix (i.e. the boxes for which the row and column labels are the same) except the lower right hand total box. Divide this sum by the total number of samples, which is equal to the value in the lower right hand box. Multiply this quotient by 100 to convert it to a percentage.

Step 9: Interpret results

- Just as the cells along the major diagonal represent all the correct classifications or agreement between the student classification of the map and the validation data collected by students at land cover sample sites, the cells, which are of the major diagonal, represent incorrect classifications or the difference.

Reporting the Data

Report all difference / error matrices to the GLOBE Student Data Base

Validation Data

		MUC Code 0222	MUC Code 0221	MUC Code 1121	MUC Code 811	Total
Map Classification	MUC Code 0222	A1:	B1: 1	C1:	D1:	E1:
	MUC Code 0221	A2:	B2: 1	C2:	D2:	E2:
	MUC Code 1121	A3:	B3:	C3: 1	D3:	E3:
	MUC Code 811	A4:	B4:	C4:	D4: 1	E4:
	Column Total	A5: 0	B5: 2	C5: 1	D5: 1	E5: 4

E5 = A5+B5+C5+D5 = E1+E2+E3+E4

(Column total) (Row total)

Overall Accuracy = $\frac{A1+ B2+C3+D4}{E5} \times 100 = \frac{3}{4} \times 100 = 75\%$

Table LAND – P – 6: Difference / Error Matrix Example

Validation Data

Classified Data (Map)

	F	W	U	Row Total
	28	14	15	57
	1	15	5	21
	1	1	20	22
olumn Total	30	30	40	100

Land Cover Categories

F = Forest
W = Water
U = Urban

Producer's Accuracy

F = 28/30 = 93%
W = 15/30 = 50%
U = 20/40 = 50%

User's Accuracy

F = 28/57 = 49%
W = 15/21 = 91%
U = 20/22 = 91%

Overall Accuracy 63/100 = 63%

Figure LAND – P – 17: A Difference / Error Matrix for Broad Land Cover Categories

SEASONS

Introduction

The Big Picture

GLOBE student observations of the atmosphere, surface water, soil moisture and temperature and vegetation all are impacted by seasonal changes as Earth orbits the sun. These seasonal changes illustrate the interconnectedness among these aspects increasing or decreasing levels of solar energy input.

This chapter has two major areas of emphasis:

- Learning science content
- Developing investigation skills

Why are there Seasons?

Like tides washing regularly across a beach, seasons advance and retreat across the face of the globe and bring changes that transform the face of the Earth.

All seasonal changes are driven by changes in the amount of the Sun's energy reaching the Earth's surface (i.e., the amount of insulation). For example, more energy leads to higher temperatures, which results in more evaporation, which produces more rain, which helps plants to grow.

Changing day length implies that the Earth's axis of rotation is inclined with respect to the plane of its orbit around the sun.

Latitude

Insulation levels vary with latitude. Because of this variation, latitude has a powerful influence in determining seasonal conditions and the annual patterns of environmental and climatic parameters such as precipitation and temperature.

Different Climatic Zones

The same season can be quite different in the Tropical, Temperature and Polar Zones. These seasonal differences are based on the duration and directness of insulation.

Continental and Marine Climates

Marine climates have large amounts of moisture and smaller temperature changes from summer to winter than continental climates. However, the size of a continent affects both the temperature range and the amount of moisture in the interior the larger the continent the large the effect.

Two key factor that affect precipitation levels

- Amount of Water Vapour
- Temperature

Geographical Features (GF)

G. F has profound impacts on nearby regions.

Elevation

Changes in elevation can affect the environment as much as changes in latitude.

How are Components of the Earth System Impacted by Seasonal Changes?

The atmosphere is perhaps the most obvious in its seasonal changes. There are annual cycles in temperature and precipitation. Hurricanes and tropical storms are season dependent, as are droughts and monsoons.

Earth ecology has adapted to Earth's seasonal changes in some remarkable ways. Animals migrate during the year to avoid extreme conditions. Most species have annual reproductive cycles. Plants have their highest photosynthesis levels in the summer when the sun is highest. Seeds germinate when soil temperature and moisture conditions are favourable.

Soil conditions vary seasonally. For example, seasonal biological changes such as leaves falling enrich the soil.

The hydrologic cycle shows seasonal changes in all aspects of the cycle. Pacing and dry seasons affect the quantity and quality of water in rivers and lakes.

◆

Determining the percentage tree canopy cover:

$$\% \text{ Tree Cover} = \frac{\text{Total ``T'' Canopy Observations}}{\text{Total Observations}} \text{ X } 100$$

Determining the percentage evergreen canopy cover:

$$\% \text{ Evergreen Cover} = \frac{\text{Total ``E'' Canopy Type Observations}}{\text{Total Observations}} \text{ X } 100$$

Determining the percentage deciduous canopy cover:

$$\% \text{ Deciduous Cover} = \frac{\text{Total ``D'' Canopy Type Observations}}{\text{Total Observations}} \text{ X } 100$$

Determining the percentage graminoid canopy cover:

$$\% \text{ Graminoid Cover} = \frac{\text{Total ``GD'' Ground Vegetation Type Observations}}{\text{Total Observations}} \text{ X } 100$$

Determining the percentage shrub canopy cover is more complicated. If shrubs occur under trees, the canopy cover is tree not shrub.

$$\% \text{ Shrub Cover} = \frac{\text{Total Observations where Shrubs are the tallest vegetation}}{\text{Total Observations}} \text{ X } 100$$

Determining the percentage dwarf shrub canopy cover is also more complicated. If dwarf shrubs occur under trees or shrubs, the canopy cover is tree or shrub and not dwarf shrub.

$$\% \text{ Dwarf Shrub Cover} = \frac{\text{Total Observations where Dwarf Shrubs are the tallest vegetation}}{\text{Total Observations}} \text{ X } 100$$

Chapter VII

FREQUENTLY ASKED GLOBE QUESTIONS

General Information

Q: What is The GLOBE Program?

A: GLOBE is a worldwide hands-on, primary and secondary school-based science and education program.

For Students, GLOBE provides the opportunity to learn by:

- Taking scientifically valid measurements in the fields of atmosphere, hydrology, soils, and land cover/phenology - depending upon their local curricula.
- Reporting their data through the Internet to the student data archive.
- Creating maps and graphs on the free interactive Web site to analyse data sets collaborating with scientists and other GLOBE students around the world

For Teachers, GLOBE provides assistance through:

- Training at professional development workshops
- Teacher's guides, "how-to" videos, and other materials
- Continuing support from a Help Desk, scientists, and partners
- Contact with other teachers, students, and scientists worldwide in Web Chats and list servers

For International and U.S. Partners, GLOBE provides:

- Train-the-Trainer workshops
- Guidance and support for mentoring teachers

Q: What is the Value of GLOBE?

A: "GLOBE is the quintessentially ideal program for involving kids in science," - Nobel laureate Dr. Leon Lederman.

GLOBE trains teachers to help students improve their achievement in science and math, and in the use of computer and network technology.

GLOBE helps teachers and students achieve state and local education goals and standards.

GLOBE increases student awareness about their environment from a scientific viewpoint, without advocacy relative to issues.

GLOBE improves student understanding of science because it involves them in performing real science - taking measurements, analyzing data, and participating in research in collaboration with scientists.

GLOBE students contribute data for scientists to use in their research.

GLOBE helps expand the pipeline of potential future scientists and researchers for industry, academia, and government.

Q: Who is involved in GLOBE?

A: GLOBE is a cooperative effort of schools, led in the United States by a Federal interagency program supported by NASA, NSF, EPA and the State Department, in partnership with colleges and universities, state and local school systems, and non-government organizations. Internationally, GLOBE is a partnership between the United States and 97 other countries.

Over a million primary and secondary students in more than 10,000 schools have taken part in the program; there are more than 16,000 GLOBE-trained teachers and those numbers are growing!

Parents and others can work with teachers to help students obtain data on days when schools are not open.

Q: How to Join GLOBE?

A: Teachers and other educators who wish to lead students in GLOBE need to attend special workshops in order to fully participate in the program. Internationally, contact your Country Point of Contact. In the U.S. look up currently scheduled workshops here and if you do not find a workshop you can attend, contact a Partner in your state or area. If you have any problems in the U.S., contact the Help Desk.

Q: How can one GLOBE school identify other GLOBE schools to collaborate with? How can they identify a GLOBE school in another country?

A: The list of GLOBE schools in partner countries is available via the School Search feature, which is also available on the GLOBE Menu Bar (at the GLOBE Website – www.globe.gov) access, you can contact the teacher using GLOBE Mail to discuss collaboration. If the school does not have web access, contact information will be provided for the school.

Q: How do you hope students will benefit from GLOBE?

A: With the help of this program, students will learn how to determine the health of an environmental system. Society assumes that we can keep dumping pollutants and somehow the environment will take care of them. In this program, Students have the opportunity to check their water system and can know whether the water systems are polluted or healthy. Also they can learn how to make good measurements.

Atmosphere Protocol

Q: What kind of data is expected to be collected in atmosphere protocol by GLOBE Students and why?

A: GLOBE is interested in rainfall and clouds because they affect the amount of sunlight that comes in – the sun provides the energy for the whole planet. This is what drives life. GLOBE need to know how much sunshine is coming in and what kind of clouds might be reflecting sunlight away. The clouds also tell us about how much water vapor is in the atmosphere and that helps us understand the hydrologic cycle, probably the most critical cycle on earth.

Q: Why do students have to report cloud cover observations even if there are no clouds?

A: It is just as important for scientists to know when there are no clouds in the sky as when there are clouds. Please always report the cloud cover, even on a beautiful day with blue sky! How could you accurately calculate average cloud cover if data were always missing for completely clear days?

Q: Students have been taking cloud cover observations for GLOBE for several years; why has the Cloud Cover Protocol changed to include new categories?

A: The addition of the isolated category was made necessary by a change in the way that scientists and trained meteorological observers take their cloud observations. The old scattered category was divided into two categories. This is important, particularly for pilots, because they need to know when clouds first form and also when they begin to cover more than 50% of the sky. The old scattered category simply covered too wide a range of values (10-50%) to be of great use to pilots, so observation standards changed. GLOBE protocol has been changed to better match these standards, and in this way, make the GLOBE cloud cover observations of more use to scientists. The addition of the obscured category was done to account for the very real possibility that the clouds may not be seen on some days due to natural weather obstructions. In the past, fog was lumped with stratus clouds and there was no clear guidance as to what to report if the sky was obscured for other reasons.

Q: Can't an instrument be designed to measure cloud cover?

A: Yes, in fact, lasers are used to measure this and the instrument is called a ceilometer. Ceilometers measure the portion of the sky covered by clouds; but they are very expensive. Furthermore, the ceilometers in use today only provide accurateestimates of cloud cover up to heights of about 3.5 kilometers, which makes them useless for most middle clouds and all high clouds. Cloud cover is an aggregate of all clouds at all levels, and human observations are still the best way to measure this at this time.

Q: Is there any way to make sure that observations made by students are accurate, since there is no instrument to calibrate?

A: These data are very important, and practice will help students to become proficient in estimating cloud cover. They can compare their own observations with nearby neighbors' observations, and compare them with "official" observations, too, to learn about how accurate their own observations are; but remember that on some days the cloud conditions will be different even over short distances and they may change in minutes. If students do them diligently every day, they will become very comfortable with their efforts!

Q: Is the cloud type observation system in GLOBE unique or new in some way?

A: This system is the same one that meteorologists have been using for two hundred years. Many scientists started to observe the sky and note how it was different (in terms of cloud types) from one day to another. The scientific basis of this cloud type observing system has not changed substantially since it was first devised. The systematic breakdown of clouds into ten basic types was motivated at least in part by the classification of species of living things into the Animal and Plant Kingdoms by biologists. In fact, meteorologists often further divide the cloud types into other specific variations within each cloud type. Castellanus refers to castle-like turrets in a cloud formation, an indicator that the atmosphere is becoming unstable, perhaps foretelling precipitation. Lenticularis means lens-shaped, a cloud often formed over high mountains. And cumuli are often separated into humilis (fair weather, puffy) or congestus (towering, heaped like cauliflower, very tall).

Q: If students missed reading the maximum/minimum thermometer for a day or more (over the weekend, holiday, vacation, etc.), can they still report the temperature for today?

A: Students can and should report the current temperature. They may not report the maximum and minimum temperatures, as they are the maximum and minimum temperatures for more than one day. The indicator has to be reset so that they can report the maximum, minimum, and current temperatures after a day.

Q: Why do students have to check the rain gauge every day, even if they know it hasn't rained?

A: The problem with containers like a rain gauge is that they tend to collect more than just rain. Leaves, dirt, and other debris can quickly spoil the rain gauge as a scientific instrument. This debris can block the funnel, causing rainwater to flow out of the gauge. Even if the debris is not large enough to block the funnel, it may become mixed in with the rainwater and affect the level of precipitation reading or the pH reading.

Therefore, it is very important that they check the gauge daily to make sure it is free of dust and debris.

Q:- Does our instrument shelter have to have slats?

A: It is important that air be able to pass freely into and out of the instrument shelter so that the thermometer measures the ambient air temperature. The salts on the instrument shelter allow air to move through the shelter, but also help to keep out rain, snow, and blowing debris. Just putting holes in the walls of the shelter will let in more rain or snow than the slats will. So yes, it is very important for the instrument shelter to have slats. For more insight to the characteristics of the instrument shelter, see the Learning Activity on Studying the Instrument Shelter.

Q:- Why does the instrument shelter have to be white?

A: The role of the instrument shelter is to protect the thermometers from direct sunlight, as well, as from precipitation and flying debris. However, we want to make sure that the instrument shelter itself doesn't affect the air temperature being measured. That is, we want the air temperature inside the shelter to be the same as the air temperature in the shade outside the shelter. This means that we want a shelter that won't absorb a lot of sunlight and heat up more than its surroundings. By making the shelter white, most of the sunlight that hits the shelter is reflected away. For more insight to the characteristics of the instrument shelter, see the Learning Activity on Studying the Instrument Shelter.

Q:- Must our snowboard be made of plywood?

A: Plywood is best, but other lightwoods may be used. Metal is not appropriate as it can warm up too much in sunlight and melt the initial snow of a day time snowfall. The kay is that the snowboard is light enough to be placed on the surface of the snow and not sink the snow pack.

Q:- We live in a city where is not a good area on the school grounds to place our rain gauge and instrument shelter. Can we put these instruments on the roof of the school?

A: Although this is not the best location for weather instruments, if your choice is between putting the instrument on the roof or not participating in the Atmosphere Investigation, put the instruments on the roof. This has several disadvantages, both to students and scientists.

- Someone will need daily access to the roof to take the reading unless automated equipment is used.
- At the height of even a single-story building, the wind effect on your rain gauge is going to be worse than it would be on the ground.
- You must take care that structures on the roof don't block the rain gauge.
- The roof of a building is likely to be much warmer than its surroundings. The heat coming off the roof is likely to affect your temperature measurements. One way to curt down on this effect may be to put some kind of material like artificial or real grass down on the area underneath your instrument shelter.
- By putting the weather instruments on the roof, the measurements made will not be easily comparable to schools where the instruments are located on the ground. However, this does not mean that the measurements aren't useful. Eventually your school will develop a data record that will show if there are any changes in precipitation or temperature over time.

For cloud and aerosols observations, the roof can be an excellent location if your school is among the tallest building around.

Any time you are unable to strictly follow the protocol for placing your instruments, be sure to make a note of this in your site description. This way other students and scientists who use your data will be aware that there are special circumstances.

Q:-Is it okay to mount our instrument shelter on a tree?

A: While this may seem to be reasonable place for the shelter, since a tree will protect the thermometer from sun and precipitation, a tree is thermometer from sun and precipitation, a tree is NOT a good place for the instrument shelter. Why? Because a tree is a living thing. This means that in the process of making food and growing, a tree gives off heat and moisture that may affect your temperature reading. Also, a large tree may provide too much shelter and not allow wind to flow freely through the instrument shelter.

Q:- Can we put our rain gauge on the ground?

A: To minimize effects of the wind, placing the rain gauge at ground level will help reduce errors, but whether or not this is a good idea in practice depends on several factors. Most of all, the rain gauge must be stable. You don't want to just place it on a surface where it may get blown over by the wind or accidentally knocked over. That is, even if you want to put your rain gauge at ground level, you must still be certain that it is firmly attached to a post that will keep the gauge upright. Another consideration is the type of surface on which you are placing the gauge. A hard surface, such as concrete or asphalt, may increase the chance that rain will splash into the gauge from the ground. In this case, it would be best to have the top of the gauge at least 50 centimeters above the ground. However, if the surface is a porous natural surface, the gauge can be placed very close to the ground with little problem of splash in.

Q:- Why does the instrument shelter have to face away from the equator?

A: When you go outside on a sunny day, it is quickly obvious that you feel much warmer standing in direct sunshine than standing in the shade. For GLOBE temperature measurements, we want to measure the temperature of the air, without the influence of direct sunshine. In order to get an accurate measurement of air thermometer is protected from direct sunshine. This means that in the Northern Hemisphere the instrument shelter should face north, and in the Southern Hemisphere the instrument shelter should face south. In this way, sunlight will not shine directly onto the instruments in the shelter when the shelter door is opened to take a reading.

Q:- We don't have access to a GPS receiver at present to define the location of our Atmosphere Study Site; what should we do?

A: You should define your Atmosphere Study Site and choose for its location the coordinates of your school. Later, when you have access to a GPS receiver, use it to measure the latitude, longitude and elevation of your site and report these data to GLOBE by editing the definition of your Site. Information about obstacles, the heights of the various instruments, etc. can also be reported after data collection and reporting have begun by editing the definition of your site.

Q:- Why do we have to report cloud cover observations even if there are no clouds?

A: It is just as important for scientists to know when there are no clouds in the sky as when there are clouds. Please always report the clouds cover, even on a beautiful day with blue sky! How cover if data were always missing for completely clear days? Also be aware that clear sky is the easiest measurement from the ground, but the hardest to determine with confidence from satellite imagery.

Q:- Can't an instrument be designed to measure cloud cover?

A: Yes, in fact lasers are used to measure this and the instrument is called a ceilometer. Ceilometers measure the portion of the sky covered by clouds, but they are very expensive. Further more, many of the ceilometers in use today only provide accurate estimates of cloud cover up to heights of about 3.5 k/m, which makes them useless for most middle clouds and all high clouds. Clouds cover is an aggregate of all clouds at all levels, and human observations are still the best way to measure this from the ground. Also, ceilometers take only a single point or profile measurements that may not be representative of the overall cloud cover.

Hydrology Protocol

Q: Is GLOBE concerned about things that are put in water by natural sources? By human sources? By both?

A: Both. Impurities – and impurities don't mean anything that's necessarily bad, just anything other than water – can get in the water because rocks, dust and gases dissolves. Some impurities come from the atmosphere in rainfall and snowfall, which then enter streams and lakes. Some impurities come when humans dump waste into streams and lakes.

Q: What is the difference between what we are measuring with the pH protocol and what we are measuring with the alkalinity protocol? Both relate to the acid or base nature of water.

A: The pH is a measure of the relative acid content of water. Water with pH 5 has 10 times the acid content of one with a pH of 6, i.e., pH is a logarithmic scale with lower numbers indicating a greater acid content. Alkalinity is a measure of the resistance of water to changes in pH when acid is added to the water. It is a linear scale. In water we want to know how much acid (from rain or snow or dust, etc.) a lake or stream can receive before pH begins to change significantly.

Q:- It is acceptable to make a small hole in the transparency tube near the bottom, fill the tube with water, then slowly release water until the disk at the bottom appers?

A: This method is acceptable as long as the measurement is made very quickly. Particles settle quickly, especially if they are being pulled down by water being released at the bottom. The reading must be made before particle settle and obscure the disk. These tubes should be emptied and the rinsed between readings to be sure no particles remain on the bottom to affect the next reading.

Q:- It is acceptable to use a man-made site, e.g. a pond built near the school?

A: Although natural sites are first in the order of preference, man-made sites may be used. Many lakes and ponds are man-made.

Q:- We live fairly near to a river, but my class can't go that far for sampling every week. Should we choose a less preferable, but closer site?

A: Try to sample water bodies that are significant to your area, even if you have to use a less frequent sampling strategy. Sites closer to the school, that can be sampled weekly, can also be chosen as a second sampling site. This often makes for interesting comparisons between the sites.

Q:-Can I choose a site that is sometimes dry?

A: Water sites may sometimes dry up, be frozen, or become flooded so that data cannot be collected. If one of these situations occurs, check 'dry', 'frozen' of 'flooded' on the data entry page for each week that you cannot collect a water sample. This will indicates to researches that the site being monitored even though water data cannot be collected.

Q:- Can I have more than one site on a river or lake?

A: Multiple sites along a watershed are desirable. Significant difference might be found at sites with different depths, near different land cover, or in tributaries of a larger river or body of water.

Q:- why is the water temperature sometimes colder and sometimes warmer than air temperature?

A: Water has a higher specific heat than air. This means it takes water longer to heat up and longer to cool down than it does air. As a result, air responds much more quickly than water to changes in temperature.

Q:-Why does the amount of dissolved oxygen I measured not agree with the amount I calculated?

A: There are two reasons why these numbers may not match. First, you may not have followed the instruction on your kit exactly or you may have made small errors in the procedure you used. Here are some trouble-shooting tips:

1. Make sure you do not have any air bubbles in your sample bottle or your titrator (for kits use a titrator). To check for air bubbles in the sample bottle, turn the bottle upside down while it is capped and look for bubbles.
2. Measure accurately. If you are adding drops from a bottle, hold the bottle vertically so that all of the drops are the same size.
3. Allow all of the precipitate to settle. If you shake the bottle too hard before the precipitate settles, it may take 10 minutes or more for the settling to happen.
4. Record accurately. If your kit asks you to count drops, have two people count to insure accuracy. If your kit asks you to read a titrator, make sure to read the instructions for accurately reading the titrator that come with your kit. The Second reason your measured value may not be the same as your calculated value is that there may be something wrong with 6the chemicals in your kit. In this case, you will need to get new chemicals.

Q:- Why do we have to do the measurements at the same time of day?

A: The amount of dissolved oxygen may change during the day as the water begins to warm up. More light penetrating the water causes more photosynthesis to occur. This can also increase the amount of dissolved oxygen. For this reason it is important to do your Hydrology measurements at the same time of day each week.

Q:- What will make my dissolved oxygen levels change over the year?

A: Besides seasonal differences in temperature, seasonal changes in the flow of your stream, changes in transparency, or changes in productivity (amount of growth of plants and animals in the water) will cause changes in dissolved oxygen levels.

Q:- What happens to the conductivity meter reading if my water is really salty or brackish?

A: Most meters will only measure up to 1990.0 uS/cm. If your water has higher conductivity than this, the meter will not give a reading. You should use the Salinity Protocol to measure the dissolved solids in your water.

Q:- Why could I not find a color match with the pH paper?

A: The conductivity of your water might be low (see Electrical Conductivity Protocol). The pH paper takes longer to react with the water if the conductivity is less than 400 microSiemens/cm (mS/cm). If your water has a conductivity of less than 300 mS/cm, some pH paper does not work well. Another reason you may have problems is if your pH paper is old or has not been stored properly.

Q:- What do I do if the pH seems to be between two color matches on the box?

A: Report the match 6that is the closed. This is the reason we have three students do the protocol. Taking the average of the three reading gives a more accurate measurements.

Q:-Does water temperature affect my pH reading?

A: A change in water temperature can actually change the pH value of your water. Since we want to know the actual pH value, we do not correct for this change.

Temperature can also affect the performance of the meter. The electrode is designed so there is no temperature sensitivity when the pH s is 7.0. As the pH moves away from this value, the water temperature affects meter accuracy. Meters with automatic temperature compensation (ATC) correct for the temperature of the water at values above and below 7.0 by a factor of 0.003 pH/C/pH unit away from pH 7. They correct for meter error. They do not correct for actual changes in pH.

Q:- Does high salt concentration affect pH?

A: Salt concentration can affect pH. As salt concentration increases, pH can increase. This is not a linear relationship, but can be important in estuaries, where the salinity varies with the tide. Taking into account salinity or conductivity data may be useful in understanding variations in your pH measurements.

Q:- Why may pH measurements be inaccurate in low conductivity waters?

A: To measure the hydrogen ion concentration, you are actually measuring the potential of the hydrogen ions. Other ions have to be present to pass the current to make this measurement. When they are at too low of a concentration the mater slowly drifts and if the drifts is really slow, the meter locks in on an incorrect measurement.

Soil Protocol

Q: What kind of data does the GLOBE want from GLOBE students in soil protocol?

A: Students will examine samples of soil from their study site and study them in a variety of ways. GLOBE want them to become familiar with soil particles so as to have better understanding of how moisture flows in soil, how soil relates to vegetation, how it affects the climate, and so on.

Q: Have students collected data before for soil investigation?

A: Not at this level. Most work has been done by individual scientists, never by this great worldwide sampling effort.

Q: On the intermediate soil moisture measurements in GLOBE, how many soil samples are students supposed to take?

A: Intermediate level students should take 11 samples (every 5 m along a 50 m transect located in an open field) once a month. The following month, offset 10-25 cm from the previous sample location and collect 11 more regularly spaced samples. Every three months, collect three samples from within 25 cm of ONE sample location to evaluate soil and sample variability. This makes for a total of 13 samples this month.

If this is a problem because you only have 12 cans, either use some other type of closed container (baby food jar) or drop one of the other sampling points.

Land Cover Protocol

Q. In the biology pixel, we are required to measure the most dominant species. Does this depend on the most frequent species or the species which produces the most canopy?

A: The dominant species and co-dominant species both must reach and occupy the canopy. The dominant species is defined as the most numerous species occurring in the canopy, and the co-dominant is defined as the second most numerous species in the canopy. Except in unusual cases in which crown morphology (shape) differs greatly between dominant and co-dominant species (i.e. one with a rounded crown - like amaple, and one with a columnar crown - like a fir tree), the more numerous species will occupy a greater percentage of the canopy. Assuming both species are in the canopy, a count of trunks for each species will identify the dominant and co-dominant species, based on numbers.

Q. In my biology site, trees are not very abundant. What do I consider to be the dominant species in my site?

A: The dominant species is the tree species, even if just a few occur within the site. Any ground cover, for example moss, will likely dominate a site, but would not be the dominant tree species. The measurement of canopy closure and ground cover presented at the workshops will allow the scientist to estimate the relative influence of canopy vs. ground cover for the site.

Global Positioning Systems (GPS)

Q: What is GMT (UTC)?

A: GMT (Greenwich Mean Time) and UTC (Universal Time Co-ordinate) are basically the same. UTC is based on atomic measurements rather than the earth's rotation, and the timing system is independent of your location and has been used by scientists to synchronize observations from around the world. Using it will allow teachers and students to coordinate their measurements as well. All receivers, which are sent out for The GLOBE Program, should be pre-set to the UTC time option. If the time does not indicate this setting it can be changed through the set-up options using the operator's manual. When you read a time followed by "UT" from the receiver then you are reading Universal Time.

Q: What kind of data do the GLOBE need with the GPS?

A: GLOBE needs the latitude, longitude and the elevation above sea level so that they can locate the site on the satellite images. The other scientists want to know exactly where you are in these pictures so that they can compare measurements in one location to measurements in other locations.

Data Entry

Q: Several of the atmospheric measurements must be taken within an hour of solar noon. How do we calculate our local solar noon?

A: Solar noon is the time during the day when the sun appears to have reached its highest point in the sky. Astronomers refer to this time as local apparent noon. Usually, this is not the same time as "clock noon". The relationship between clock noon and solar noon depends on your location within your time zone and the time of year.

Solar noon always occurs half-way between local sunrise and sunset. Therefore, an easy way to calculate your local solar noon is to find a newspaper from a nearby town that gives the times of sunrise and sunset and to take the average of these. Remember to first convert all your times to 24-hour clock times by adding 12 to any PM times before calculating the average of the sunrise and sunset times. The result is the time of your local solar noon.

Here's how the math is done: Add the two times and divide by two. Remember, however, that doing math with time is a bit tricky because there are 60 minutes to an hour.

For example, adding 0:45 and 1:30 equals 2:15 (two and a quarter hours), not 1:75 (one and three-quarters hours). Here's the actual calculation:

45 minutes + 1 hour 30 minutes = 1 hour 75 minutes = 2 hours 15 minutes

75 minutes = 1 hour 15 minutes (convert 60 minutes to an hour and you have 15 minutes remaining).

Now let's look at dividing times.

Half of 25:18 is actually 12:39, not 12:59. Here's the actual calculation:

1. First, divide the hours by 2. So 25 divided by 2 equals 12 with 1 hour remaining.
2. Next, convert the remaining 1 hour to 60 minutes and add this to the 18 minutes. The sum of 60+18 gives you 78.
3. Now, divide 78 by 2. You get 39 minutes. Thus, the final result is 12:39.

There are two ways to find the solar noon (or to check your own calculations).

1. Calculate Solar Noon based on sunrise and sunset times you supply.
2. Calculate Solar Noon based on a specific longitude and date.

Remember to convert this time to UT before entering it on the data entry form.

Q: What is UT or UTC (GMT) and why do we use it? How do I convert my local time to UT?

A: UT (or UTC) stands for Universal Time Co-ordinated (replacing GMT, or Greenwich Mean Time). UT is based on atomic measurements rather than the earth's rotation (as GMT was based on).

The primary reason we use UT is to base the recording of our scientific experiments against a reference time. People live in different time zones. For example, 5:00 p.m. in Denver, Colorado is not the same time as 5:00 p.m. in Sydney, Australia. If we all record our experimental data in reference to UTC, everyone knows exactly when those measurements were taken.

To convert your local time to UT, first make sure your local time is in 24-hour format (e.g., 1:00 p.m. is 1300). Then consult a time zone map to figure out how many time zones your site is away from Greenwich, England, which is still the reference site for UT. You will find time zone maps in a variety of places; one online reference is available from the U.S. Navy at:

http://www.globe.gov/arc/faq/exit.cgi? http://tycho.usno.navy.mil/tzones.html

Once you have found the difference between your local time and UT, add or subtract that difference from your local time. The resulting time is in UT.

If you live in an area that uses Daylight Savings Time, the amount that you add to your local time will be one hour less during the summer, when Daylight Savings Time is in effect. For example, in the U.S., seven hours are added to Pacific Standard Time to convert it to UT during the summer, while eight hours are added during the winter.

Sometimes it may be difficult to determine where you are on the time zone map. For instance, the map shown at the above web site displays the entire world and does not show much detail of any particular region. You may live near a time zone boundary and not be sure on which side of the line you fall. If this is the case, you may want to look at the clock in UT on the Atmosphere Investigation data entry sheet and compare that time with your local time. Once you have calculated the difference, you can apply this correction to the times of your observations.

Q: What does a student do if he/she enters wrong data and want to correct it?

A: If a student inadvertently enters incorrect information onto the Student Data Server, he/she can correct the error simply by re-entering the correct data. Make sure to indicate that the measurements were taken at the same time as the previous entry made by the student. If the GLOBE data processors see two sets of data for the same time, they will assume that the set that was entered later is the correct data.